



R&D project evaluation: An integrated DEA and balanced scorecard approach[☆]

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Abstract

We present and demonstrate a multi-criteria approach for evaluating R&D projects in different stages of their life cycle. Our approach integrates the balanced scorecard (BSC) and data envelopment analysis (DEA) and develops an extended DEA model. The input and output measures for the integrated DEA–BSC model are grouped in “cards” which are associated with a “BSC for R&D projects”. The BSC is embedded in the DEA model through a hierarchical structure of constraints that reflect the BSC balance considerations. We illustrate the proposed approach with a case study involving an industrial research laboratory that selects and executes dozens of R&D projects every year.

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1. Introduction

This paper develops an analytical model aimed at evaluating research and development (R&D) projects in different stages of their life cycle. It may be applied to project proposals—as part of a project selection procedure, or to ongoing projects—during their initiation, planning, execution or closing stages. Based on the evaluation, management has to decide which project proposals should be selected, which ongoing projects should be continued, or which resource level should be associated with each selected or continued project. The evaluation of projects at their closing stages should allow

the creation of a knowledge base of “best practices” and “lessons learned” that would be communicated throughout the organization for continuous learning.

The R&D project evaluation problem is a challenging decision-making problem faced by decision makers that deal with R&D management. The evaluation involves multiple criteria measuring rewards, relevance to the organization’s mission and objectives, strategic leverage potential, probability of technical and commercial success, etc. Once the criteria are determined, they should also be weighted to reflect the preferred emphasis of the organization. The focus on future events and opportunities in a dynamic environment cause much of the information required to be at best uncertain and at worst unavailable. Opinions and judgments often have to substitute for data, and measures could be estimated only qualitatively. While quantitative measures like return-on-investment (ROI) are sometimes hard to estimate, qualitative metrics like market familiarity and customer

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satisfaction are potentially important. The lack of reliable quantitative measures is especially apparent in not-for-profit organizations, where qualitative measures usually take a larger share in the overall evaluation.

Despite these difficulties, projects should be evaluated and prioritized, as they compete for resources. The model we propose in this article tries to respond to these challenges by integrating two well-established managerial methodologies: balanced scorecard (BSC) [1] and data envelopment analysis (DEA) [2].

The BSC is a management tool composed of a collection of measures, arranged in groups, and denoted as *cards*. The measures are related to four major managerial perspectives, and are aimed at providing top managers with a comprehensive view of their business. The cards offer a balanced evaluation of the organizational performance along financial, marketing, operational and strategic dimensions. BSC combines financial and operational measures, and focuses both on the short- and long-term objectives of the organization. It was motivated by the realization that traditional financial measures by themselves are inadequate in providing a complete and useful overview of organizational performance. In [1], a number of different BSC structures are presented for different industries. Indeed, many organizations have adopted the BSC approach to accomplish critical management processes, clarify and translate their vision and strategy, communicate and link strategic objectives and measures, plan and align strategic initiatives, and enhance strategic feedback and learning. A specific BSC model for projects was first suggested by Stewart [3].

DEA [2,4] is a mathematical programming technique that calculates the relative efficiency of multiple decision-making units (DMUs) on the basis of observed inputs and outputs, which may be expressed with different types of metrics. The basic concept in DEA is to measure the efficiency of a particular DMU against a projected point on an “efficiency frontier”. The usefulness of DEA in evaluating multi-criteria systems and providing improvement targets for such systems is expressed in the large number of its reported applications, as described in [5]. Specific DEA models for the context of technology selection or R&D project evaluation were suggested by Oral et al. [6], Khouja [7], and Baker [8].

The method that we propose in this paper uses an extended DEA model, which quantifies some of the qualitative concepts embedded in the BSC approach. The integrated DEA–BSC model addresses three common goals that firms are trying to accomplish [9,10]:

(1) achieving strategic objectives (effectiveness goal); (2) optimizing the usage of resources in generating desired outputs (efficiency goal); and (3) obtaining balance (balance goal). The model is applicable for evaluating R&D projects in for-profit, private organizations (e.g., venture capital funds), as well as in not-for-profit organizations, such as government agencies charged with selecting R&D projects.

The contribution of the model that is presented in this paper is both conceptual—the integration, for the first time, of the BSC into the DEA model through balance constraints, and theoretical—the introduction of a hierarchical structure of balancing constraints that restrict the proportions of the total output/input of any given DMU that are devoted to specific output/input measures. While traditional weight restriction techniques in DEA (see the literature review) focus on restricting the weight flexibility of the individual weights, the model presented here focuses on balancing the “importance” attached to groups of measures, and applies it within a hierarchical balance structure. The model is also practical because it supports the evaluation of projects throughout their life cycle—during the selection, planning, execution, and termination phases—while relying on the popular BSC measurement system. It also pays attention to the goals that concern managers—namely, effectiveness, efficiency, and balance.

The rest of the paper is organized as follows: Section 2 provides a literature review; Section 3 develops a specific BSC for R&D projects. The integrated DEA–BSC model is presented in Section 4, while its associated mathematical formulations are given in the appendix. Section 5 discusses a case study that applies the DEA–BSC model. Finally, Section 6 presents concluding remarks.

2. Literature review

Over the last few decades, the problem of R&D project evaluation has attracted significant attention that has led to a variety of methods. These methods seek to develop quantitative measures to assess the performance of R&D projects by systematically obtaining and integrating subjective and objective data. The methods range from simple screening procedures to sophisticated mathematical procedures, and are usually subdivided into the following categories [11,12]: scoring models [13], multi-criteria decision-making (MCDM) models [14–18], comparative approaches [19–21], and economic models [13,22,23]. Comprehensive reviews of R&D project evaluation methods can be found at Baker and Freeland [11], Baker and

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