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The Implementation of a Cash-Flow-Based Mathematical R&D Project Selection Model

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ABSTRACT

Customer project selection is a challenge for many industrial companies. An inappropriate project selection approach can lead to constraint violations, high fixed costs, and suboptimal portfolios. To overcome these problems a cash-flow-based linear optimization model was developed in partnership with a tier-1 automotive supplier. Implementation barriers had been verified through a case study conducted at two organizational hierarchies. Results suggest that an application at the operating levels is possible. At higher levels, though, product and firm complexity require major implementation efforts. This article serves theorists as well as practitioners in multiple regards. First, an overview of existing project selection methods and their application in practice is provided. Additionally, the supplier's current appraisal process is depicted. Second, operations research implementation barriers are identified and validated for the adoption of the proposed mathematical project selection approach. Third, a guideline including procedures to overcome experienced difficulties is presented.

KEYWORDS

Mathematical, Optimization, Portfolio Selection, Project Portfolio, Project Selection, R&D, Research and Development

INTRODUCTION

The selection of new customer projects is essential for contract-based manufactories. Profitability must be achieved, and cash flow targets must be met (Cooper, Edgett, & Kleinschmidt, 1999). To support practitioners in their decision-making, several project selection models are discussed in theory. Empirical surveys revealed that mostly simple methods are applied in practice, whereas sophisticated mathematical approaches are neglected (Ryan & Ryan, 2002). This article studies the general applicability of operations research models at project selection. Required conditions for a successful implementation are analyzed and provisions provided. In detail, a case study on introducing mathematical project selection at a top-five tier-1 automotive supplier is illustrated. The research question this article answers is this: *Which conditions need to be present to implement operations research at project selection, and how can these conditions be established?*

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Several important aspects emerge from this article. First, detailed literature reviews on existing project selection methods, on their practical applications, and on general operations research implementation barriers are of interest, especially for practitioners. Second, the supplier's current project selection process is illustrated, and experienced problems are analyzed. Third, a mathematical model is developed, tested, and verified at the firm's divisional investment controlling department. A detailed examination of challenges that arose in a smaller operative unit as well as in a larger firm-wide hierarchy is provided. Fourth, procedures to overcome these challenges are presented for applications at both hierarchy levels. Fifth, results of the analysis demonstrate that difficulties can be overcome at the operative unit and that one barrier remains at the higher level.

This article describes an implementation approach for mathematical programming models designed for dynamic project portfolio selection in companies with complex goods. The identification of three independent barriers, as well as specified approaches on how to overcome these barriers, allows a more effective and efficient implementation of mathematical programming models than the sole focus on the mathematical model itself, as was mostly done in prior research. Therefore, the described implementation approach is scalable and flexible enough to be adopted by different companies in changing environments for diverse application areas.

The study objective of this article is the investigation of how such sophisticated mathematical programming approaches for dynamic project portfolio selection should be implemented in firms producing complex goods.

LITERATURE REVIEW

Project Selection Approaches

To structure the multitude of project selection approaches, various classifications (Augood, 1973; Baker & Freeland, 1975; Baker & Pound, 1964; Bitman & Sharif, 2008; Cetron, Martino, & Roepcke, 1967; Gear, Lockett, & Pearson, 1971; Hall & Nauda, 1990; Heidenberger & Stummer, 1999; Henriksen & Traynor, 1999; Killen, Hunt, & Kleinschmidt, 2007; J. Lee, Lee, & Bae, 1986; Moore & Baker, 1969; Pearson, 1974; Souder, 1972a, 1972b; Verbano & Nosella, 2010) have been stated in literature. Adapting Pearson's (Pearson, 1974) categorization, four clusters are defined: economic, scoring, comparative, and mathematical methods. Economic approaches base investment decisions on absolute or relative key figures such as the net present value or the return of investment (Baker & Freeland, 1975; Moore & Baker, 1969). Their simplicity (Dean & Nishry, 1965) results in a wide application in practice (Cabral-Cardoso & Payne, 1996; Cooper & Edgett, 1997a, 1997b; Cooper et al., 1999; Danila, 1989; Higgins & Watts, 1986; J. Lee et al., 1986; Ryan & Ryan, 2002; Sanchez, 1989), even though these approaches neglect multiple constrained resources (Archer & Ghasemzadeh, 1999; Näslnd & Sellstedt, 1973). Scoring models consider several factors, which are multiplied by defined weights. To compute an overall score, the obtained products are either multiplied or added (Baker & Freeland, 1975; Dean & Nishry, 1965; Pearson, 1974). Advantages are the incorporation of qualitative data (Henriksen & Traynor, 1999; Moore & Baker, 1969) and its comprehensiveness (Bitman & Sharif, 2008; Henriksen & Traynor, 1999). Disadvantages are the lack of objectivity (Cooper, 1985; Souder & Mandakovic, 1986) and the neglect of multiple constrained resources (Archer & Ghasemzadeh, 1999; Näslnd & Sellstedt, 1973). Comparative approaches, such as the AHP (Saaty, 1980), trade off one proposal against another or against an alternative subset of projects. A preference for either choice is essential to compute a final project score (Baker & Freeland, 1975; Pearson, 1974). Quantitative as well as qualitative information is respected (Archer & Ghasemzadeh, 1999; Srinivasan & Kim, 1986). The approach often serves as a communication aid (Helin & Souder, 1974; Souder & Mandakovic, 1986). Problems might arise with a multitude of projects (Archer & Ghasemzadeh, 1999; Kunz, 2007; Saaty, 1986), unplanned alternatives (Baker & Freeland, 1975), and the consideration of multiple restrictions and interdependencies (Archer & Ghasemzadeh, 1999;

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