Available online at www.sciencedirect.com

ScienceDirect

International Journal of Project Management 33 (2015) 1744 – 1754

International Journal of Project Management

www.elsevier.com/locate/ijproman

Project selection in project portfolio management: An artificial neural network model based on critical success factors

Francesco Costantino [a,*], Giulio Di Gravio [a], Fabio Nonino [b]

[a] Department of Mechanical and Aerospace Engineering, Sapienza University of Rome, Via Eudossiana 18, Rome 00184, Italy
[b] Department of Computer, Control, and Management Engineering Antonio Ruberti, Sapienza University of Rome, Via Ariosto 25, Rome 00185, Italy

Received 1 July 2014; received in revised form 7 July 2015; accepted 13 July 2015
Available online 6 August 2015

Abstract

While a growing body of literature focuses in detecting and analyzing the main reasons affecting project success, the use of these results in project portfolio management is still under investigation. Project critical success factors (CSFs) can serve as the fundamental criteria to prevent possible causes of failures with an effective project selection process, taking into account company strategic objectives, project manager's experience and the competitive environment.

This research proposes an innovative methodology to help managers in assessing projects during the selection phase. The paper describes the design, development and testing stages of a decision support system to predict project performances. An artificial neural network (ANN), scalable to any set of CSFs, classifies the level of project's riskiness by extracting the experience of project managers from a set of past successful and unsuccessful projects.

Keywords: Critical success factors; Project selection; Artificial neural network; Project risk

1. Introduction

The contemporary competitive environment, with its widespread lack of information, misleading signs and difficulties in forecasting future scenarios, makes the acquisition and management of projects investments always more risky. A recent research (Bloch et al., 2012) on more than 5,400 IT projects by McKinsey and the University of Oxford shows that half IT projects with over $15 million budget run, on average, 45% over budget and 17% fail to a point of threatening the very existence of the company.

Companies should align project portfolio with their strategic business objectives, combining performances of its components in order to maximize the shareholders' value while balancing resource allocation and risks. Some of the main objectives of the project portfolio management are the identification, the ranking, the prioritization, the selection and the authorization of projects or programs. Uncertainty and volatility are increasing day by day and managers take strategic decisions on project portfolio (like a tender's participation or a project authorization) under non-deterministic conditions. Only through the definition of accurate project selection criteria, any organization can reach its targets.

As a matter of fact, once started, a significant level of complexity affects project life cycle and different sources of risk influence its success (Cagno et al., 2007):

- indeterminateness, ambiguity or poor definition and sharing of targets;
- lack or low measurability of targets and a consequent low capability of evaluating and recognize performances;
- inadequate resource allocation, i.e., right resources but wrongly managed or insufficient resources due to a wrong estimation;
- incorrect and not detailed identification of all the customer's and company's requirements;

* Corresponding author. Tel.: +390644585260.
E-mail addresses: francesco.costantino@uniroma1.it (F. Costantino), giulio.digravio@uniroma1.it (G. Di Gravio), fabio.nonino@uniroma1.it (F. Nonino).

http://dx.doi.org/10.1016/j.ijproman.2015.07.003
0263-7863/00/

- fast evolving markets and industries with a continuous need of targets re-alignment and re-planning;
- inaccurate planning or errors in implementation of project management processes.

Having a clear identification of threats and opportunities that can arise (Hillson, 2002; Ward and Chapman, 1995) allows containing the level of uncertainty and evaluating any possible alternative in terms of project sustainability (Ghosh and Jintanapakanont, 2004). Investments in project management capability should support project portfolio strategies while enhancing operations management during the execution phase, ensuring project performances in terms of value for customers, market share and competitiveness (Elkington and Smallman, 2001). As the project success is the ultimate objective of a company, critical success factors (CSFs) affecting its future implementation should be pillars of the selection criteria.

An early evaluation of the expected economic or financial return of a project is a very tough process, pushing organizations to set up managerial levers that could help to forecast performances (Ibbs and Kwak, 2000; Thomas and Mullaly, 2007). During the tendering stage, risk analysis can support decisions, drawing all the possible scenarios that could cause an early and unsuccessful conclusion. As managers have to investigate and control risks, any tool that evaluate how critical success factors can affect performances will support in implementing adequate actions of mitigation, making the risk assessment process more reliable. Managers can reach a proper control of the projects' portfolio, balancing the overall exposure to risks, only with a clear perception of the expected results on every single project.

In this context, risk analysis can help project managers to handle a portfolio of projects with different characteristics. The process of protection from risks represents a fundamental component of the project portfolio and project management activities (Cooke-Davies, 2002; Jaafari, 2001; Raz et al., 2002) and needs systematic procedures to enable its correct application. These procedures can vary according to different organizational environments, having an effect in the planning stage and during the whole life cycle of the project, considering the requirements of all the stakeholders. Project risk management supports managerial and organizational control (Kloppenborg and Opfer, 2002; Söderlund, 2004) to minimize inconveniences, shifts and gaps from the target values, recognizing further potential risks and their relative protections (Milosevic and Patanakul, 2005) to avoid project failure.

Our research, collocating in the "factor school" according to the extensive review by Söderlund (2011), deals with the issue of making an early assessment of projects for portfolio selection as a risk management technique. Critical success factors (CSFs) are the levers that can address toward project success. According to different industries and environments, project managers have to identify the most opportune set of CSFs, trying to implement the right practices that satisfy all the stakeholders' requirements. To this extent, the paper presents an innovative approach to design a decision support system to evaluate the correlation between a desired set of CSFs and the future projects' performances. Extracting and consolidating implicit knowledge from past projects, an artificial neural network toolbox is able to analyze a given set of CSFs' and identify, with a certain degree of error, the expected level of success for project selection process in the project portfolio management.

The following sections present the development and implementation of the research path. The first section discusses the strategic importance of project selection and the project success as a crucial point in definition of selection criteria. After we examine project selection methodologies and the role of critical success factors (CSFs) and key performance indicators (KPI) in the project selection process, deepening the project implementation profile (PIP) model. The second section describes the research methodology. The subsequent sections present the model for early assessment of project success based on critical success factors of project implementation using artificial neural network (ANN). The results of the analysis on the data coming from 150 projects of a leader Italian EPC contractor and the relative academic and managerial implications are in the last section.

2. Theoretical background

Since many years, project management research has been trying to discover how to improve the ability of organizations to reach success in implementing projects (Maylor, 2001; Patanakul et al., 2012). Project portfolio management extends the objective of realizing successful projects to the alignment with strategic business objectives, but expected project success remains the main determinant for projects selection, if success means the maximization of the shareholders' value while balancing resource allocation and risks. Therefore, project selection is a process of strategic significance (Cooper et al., 2001) aimed at evaluating individual projects or groups of projects and then choosing to implement a set of them so that the objectives of the parent organization are achieved ((Meredith et al., 2015). However, too often it fails (Ghapanchi et al., 2012) due to complexity in project portfolio management caused by many factors, such as uncertainty, interrelationships among projects, changes over time and success factors that are difficult to measure (Coldrick et al., 2005).

Given the success of the project as crucial to the definition of the criteria, there is no consensus on what criteria should be used. As a matter of fact, "companies have considerable leeway in the development of their selection criteria, and different measures as well as the wide variety of industries, project types and strategy choices make inter-organizational standardization impractical" (Kaiser et al., 2015).

The process of project assessment for project portfolio selection should always consider criteria, factors and key performance indicators (KPIs). Factors are the independent variables of a project that organizations can drive, while key performance indicators (KPIs) are the significant dependent variables that measure outcomes and performances of the project (for a complete review of project management KPIs, see Luu et al. (2008). Furthermore, the definition of the criteria is fundamental. A criterion is "a principle or standard by which anything can be judged," while a factor can be described as "any circumstance, fact, or influence which contributes to a result" (Lim and