Chapter 3
Projects Portfolio Selection

ABSTRACT

The elaborated method is applied to research and development for project portfolio selection to achieve investment objectives controlling risk. DMAIC framework applies proven stochastic techniques to risk management: i) Define: Optimization resolves an Efficient Frontier of portfolios for the desired range of expected return with an initially defined increment; ii) Measure: Simulation measures Efficient Frontier portfolios calculating mean return, variance, standard deviation, Sharpe Ratio, and Six Sigma metrics versus pre-specified target limits; iii) Analyse: Analysis considers mean return, Six Sigma metrics, and Sharpe Ratio and selects the portfolio with maximal Sharpe Ratio as initially the best portfolio; iv) Improve: Optimization resolves Efficient Frontier in a narrow interval with smaller increments. Simulation measures Efficient Frontier performance including the mean return, variance, standard deviation, Sharpe Ratio, and Six Sigma metrics versus pre-specified target; v) Control: Selected projects in the portfolio are individual projects.

INTRODUCTION

Meade and Presle (2002) presented an analytic network process (ANP) as a potentially valuable method to support the selection of projects in an R&D environment. Also, Archer and Ghasemzadeh (1999) simplified the project portfolio selection process by developing a framework that separates the work into distinct stages. The fuzzy approach to statistical analysis of portfolio selection was applied by Carlssona, Fullérb, Heikkiläc & Majlendera (2007). They developed a methodology for valuing options on R&D projects when future cash flows are estimated by trapezoidal fuzzy numbers. They presented a fuzzy mixed-integer programming model for the R&D optimal portfolio selection problem.

During the 1990s, major international corporations significantly improved their R&D performance by introducing risk analysis and portfolio management methodologies, in addition to new business-specific techniques. As superior techniques were introduced, the industries realised that systematic procedures are crucial for better management of the R&D functions. This involves structured methodologies of i) Risk and decision analysis to reduce R&D risk; ii) Portfolio management to optimise the allocation of R&D capital to specific research projects to increase return on investment. Contemporarily, significant

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work was published relating to applications of risk and decision analysis and implementation of portfolio management to R&D.

The elaboration hypothetical scenario is based on a published real R&D project (Winston 2000). Risk and decision analysis generically apply to any type of business investment decision (Bernstein 1996). Contemporary risk models are stochastic and use Monte Carlo simulation. A comprehensive elaboration on investment risk applications of Monte Carlo simulation was published by Glasserman (2004).

Portfolio analysis applies to any type of business investment decision as well. The problem of portfolio optimisation was solved in the 1950s by Markowitz (1952; 1987). Markowitz applied his award-winning mean-variance method. Nowadays, stochastic optimisation is used to resolve the optimal portfolio. Stochastic optimisation models are elaborated in a book edited by Ziemba and Vickson (2006).

The book by Garland and Morey (2022) is a practitioner's guide and takes a practical approach. The guide is principles-based thereby allowing organisations and practitioners the flexibility necessary to address their specific circumstances. The principles are grounded in logic and practice and the guide explains both how and why they are applied. They are scalable and so apply from the smallest to the largest initiatives. It explains the critical importance of accountability and how to ensure consistency of decision-making rights between the accountable roles. In doing so it addresses the integration of governance at all levels in the organisation.

Six Sigma is a recognised process improvement methodology across industries, which has been generally used by R&D as well. For example, Lunau (2013) edited a book presenting a comprehensive collection of tools applicable to design for Lean Six Sigma. This toolset is necessary for the successful implementation of inventions in R&D. The book structure corresponds to the procedure in a Design for Six Sigma^{+Lean} development project with the stages Define, Measure, Analyse, Design, and Verify. This structure provides for finding and applying the required tools quickly, which hugely facilitates development projects. Specifically, relating to project portfolio selection and Six Sigma, Hu, Wang, Fetch & Bidanda (2008) presented a decision support system by using a multi-objective formulation in project portfolio selection for effectively implementing Lean and Six Sigma concepts.

To date, however, Six Sigma has not been applied to R&D risk management explicitly for ongoing R&D project portfolio selection problems. This chapter presents a Six Sigma DMAIC structured approach to the R&D portfolio selection projects focussing on the associated risk assessment and management. In addition to the conventional methodologies, the approach systematically applies the Six Sigma DMAIC structured framework to improve the process performance of the portfolio selection from an inventory of available R&D projects quantitatively and qualitatively considering the associated risk factors. In synergy with conventional methodologies, this complementary approach offers important enhancements. Ultimately, the approach systematically improves R&D Risk Management in Project Selection.

The approach conventionally uses stochastic optimisation to determine the Efficient Frontier optimal portfolios with minimal mean-variance, according to the R&D objectives and constraints. It applies Monte Carlo simulation to stochastically calculate optimal portfolio returns as well as to calculate the absolute, relative, and risk-adjusted performance measures. In due course, the approach helps to select the optimal R&D portfolio that is satisfactorily accepted for implementation, which is the crucial objective.

The elaboration of the approach is based on a published real R&D portfolio selection project at Eli Lilli, a giant pharmaceutical company in the USA (Winston 2000, Chapter 19). However, this is a hypothetical scenario, so we emulate the scenario of a real project for the elaboration.