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A MARKOWITZ-INSPIRED APPROACH TO OPTIMIZING SPACE TECHNOLOGY PORTFOLIO INVESTMENTS

Abstract

Managing a portfolio of space technology investments involves an inherent tradeoff: the decision to invest heavily in one technology to make quick progress versus the decision to invest smaller amounts in a diverse set of technologies to hedge against risk. For space agencies and commercial companies that manage a large and diverse set of technological capabilities, a breadth of factors go into technology investment decisions, including science and development priorities, higher-level policy decisions, and existing technical capacity. While these factors are typically approached qualitatively, decision-makers have identified a need for formalized processes to identify the potential value of a given space technology investment and to quantitatively compare it with other investment options.

In this work, we draw from Markowitz portfolio theory to develop a methodology to evaluate the expected risk and return of technological investments, and to determine the optimal level of investment in each asset in a technology portfolio. As opposed to financial stocks where the expected return of an asset is determined by its historical monetary returns, the value of a technology must be quantified in terms of its performance. Based on a database of over 1000 instruments used in space science missions, we define a method that factors in learning effects of production for determining relevant figures of merit for space technologies and quantifying their value as performance at cost. A method for calculating risk based on historical use of instruments across a variety of missions with different objectives is also shown. We apply this Markowitz technology portfolio methodology to a case study of heliophysics technology investment options and present a set of technology portfolios that are optimized for different values of risk tolerance. This methodology and the resulting portfolios can be used to provide decision-makers with a quantitative tool to decide what amount of a fixed budget to invest into the development of different technologies, and to visualize how these choices change with different levels of risk tolerance.