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APPLICATION OF MARKOWITZ PORTFOLIO THEORY FOR SPACE TECHNOLOGIES

Abstract

Markowitz Portfolio Theory (MPT) has been widely applied to market-traded assets like stocks or bonds to guide investment decisions. This work uses concepts from MPT to develop a new methodology for guiding investments for space technologies. The method focuses on a key question related to technology development: Given a total technology RD investment level and a set of candidate technologies, what fraction of the total investment should be allocated to each technology? Such decision-making requires data and knowledge about technology valuation under uncertain scenarios, dependencies that exist among the set of candidate technologies, and technological and mission constraints. The traditional formulation in MPT is such that expected "return" from the portfolio is maximized and risk of the portfolio is minimized. This formulation requires specification of expected return, volatility in returns (measured as its standard deviation), and covariances between pairs of candidate assets. In case of space exploration technologies, the market-trading context along with its assumptions of monetary returns, and monetary risks are not directly applicable. This research study develops a set of suitable metrics and proxy measures that can be applied in an optimization formulation relevant for technologies. Measures of net mission value are developed, along with risk, and covariances based on technology dependencies. A quadratic optimization problem is formulated, and its solution demonstrated with applications in earth-observation and heliophysics missions. The results from application of this method can serve as starting baselines for guiding planning and strategic investments for new technologies, and can aid mission architects, technology managers, and decision-makers.