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Capturing Risk in Capital Budgeting

Mun, Johnathan C.

Monterey, California: Naval Postgraduate School

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CAPTURING RISK IN CAPITAL BUDGETING

EXECUTIVE SUMMARY

Principal Investigator (PI): Dr. Johnathan Mun, Information Sciences

Prepared for:
Topic Sponsor Lead Organization: N8 - Integration of Capabilities & Resources
Topic Sponsor Name(s): CAPT, Christopher Gilmore
Topic Sponsor Contact Information: christopher.s.gilmor@navy.mil
Topic Sponsor Point of Contact: Christopher Marsh
Topic Sponsor POC Information: christopher.d.marsh.ctr@navy.smil.mil

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Project Summary

This research goal is to propose a novel, reusable, extensible, adaptable, and comprehensive advanced analytical process coupled with Integrated Risk Management to help the Department of Defense (DOD) with risk-based capital budgeting, Monte Carlo risk-simulation, predictive analytics, and stochastic optimization of acquisitions and programs portfolios. These portfolios have multiple competing stakeholders, each subject to budgetary, risk, schedule, and strategic constraints.

The research covers topics of traditional capital budgeting methodologies used in industry, including the market, cost, and income approaches, and explains how some of these traditional methods can be applied in the DOD by using DOD-centric non-economic, logistic, readiness, capabilities, and requirements variables. Stochastic portfolio optimization with dynamic simulations and efficient investment frontiers for the purposes of selecting the best combination of programs and capabilities are also addressed, as are other alternative methods such as average ranking, risk metrics, lexicographic methods, and others. The results include actionable intelligence developed from an analytically robust case study that senior leadership at the DOD may utilize to make optimal decisions.

Keywords: *capital budgeting, Monte Carlo simulation, stochastic optimization, portfolio allocation*

Background

The research applies multiple novel approaches to enhance a program's success in generating a credible and defensible return on investment (ROI) using risk-based stochastic capital budgeting techniques within the DOD. The success criteria will be to determine a defensible ROI from multiple points of view and approaches, to triangulate to a valid and reliable ROI value, and to provide guidance and intelligence to DOD decision-makers concerning the optimal program selection and portfolio allocation of resources. The analytical methods recommended in the research findings were within the constructs of a correlated portfolio of decision options that can be stochastically optimized using concepts of Markowitz efficient frontiers. Other portfolio and program selection methods such as Preference Ranking Organization Methods for Enrichment Evaluations (PROMETHEE), Elimination and Choice Expressing the Reality (ELECTRE), Multi-Criteria Analysis (MCA), and Hierarchical Scoring-Ranking (HSR) methods were also discussed.

The proposed methodologies researched include Theoretical Constructs by using a systems-dynamics approach to utilization (closed-form partial differential equation); Convolution methods to determine the frequency and quantity of use; an Analytical Framework; Empirical Impact analysis; Work-Lifecycle Total Ownership Cost with Analysis of Alternatives (cradle-to-grave lifecycle acquisitions) approach, all of which will be combined with Integrated Risk Management methodologies to run Monte Carlo simulations, advanced data analytical approaches (artificial intelligence and data science methods), strategic flexibility real options, and stochastic optimization. Economic data (total lifecycle cost, total ownership cost, acquisition cost, cost deferred, schedule, risk), logistics data (e.g., inherent availability, effective availability, mission reliability, operational dependability, mean downtime, mean maintenance time, logistics delay time, achieved availability, operational availability, mission availability, fielded capabilities, Likert levels of creative and novel technology, as well as other metrics), qualitative subject matter expert estimates (strategic value, value to society, command priorities, legal and regulatory impact scores, etc.), and market comparable metrics to operationalize various elements of DOD benefit can be used.

Findings and Conclusions

Optimizing the Navy budget requires characterization of risk in cost, schedule, and performance. This research effort conducts deep dives on risk in cost, schedule, and performance. The research goal was to propose a novel, reusable, extensible, adaptable, and comprehensive advanced analytical process and Integrated Risk Management to help the DOD with risk-based capital budgeting, Monte Carlo risk-simulation, predictive analytics, and stochastic optimization of acquisitions and programs portfolios with multiple competing stakeholders while subject to budgetary, risk, schedule, and strategic constraints.

The research concludes that the use of traditional capital budgeting methodologies used in industry, including the market, cost, and income approaches, might be grossly insufficient for use in the DOD. This is because traditional industry approaches rely on the concept of ROI, where there is a basis for cost and revenue. The DOD is not in the business of revenue generation, thereby negating the applicability of traditional ROI metrics. Minor modifications and adaptations would also be unsatisfactory, such as the use of cost deferred or cost savings. In such situations, the highest ROI tends to have the lowest cost or highest cost savings. From experience, we know that the cheapest and most cost-effective programs are not necessarily the best options for the DOD.

The research finds and concludes that traditional ROI methods can still be applied in the DOD by appending to these existing methods, DOD-centric non-economic, logistic, readiness, capabilities, and requirements variables. In addition, more advanced decision analytics such as stochastic portfolio optimization with dynamic simulations and efficient investment frontiers should be run for the purposes of selecting the best combination of programs and capabilities also addressed, as are other alternative methods such as average ranking, risk metrics, lexicographic methods, PROMETHEE, ELECTRE, and others. The results of such advanced analytical methods include actionable intelligence developed from an analytically robust case study that senior leadership at the DOD may utilize to make optimal decisions.

Recommendations for Further Research

Apart from purely financial and economic values, operational, logistic, and other values can be constructed and used in the prescribed modeling approaches, as investigated in the research. For instance, the use of operational and logistic metrics (inherent availability, effective availability, mission reliability, achieved availability, operational availability, mission availability, operational dependability, mean downtime, mean maintenance time, and logistic delay time) and alternative economic metrics (cost deterrence and avoidance, net present value, internal rate of return, return on investment, total ownership cost, total lifecycle cost, knowledge value added) embedded within cross-domain requirements, budgetary restrictions, as well as other strategic and capability constraints. Further analysis of the use of these metrics is recommended in any follow-on and future research.

Acronyms

ELECTRE	Elimination and Choice Expressing the Reality
DOD	Department of Defense
HSR	Hierarchical Scoring-Ranking
MCA	Multi-Criteria Analysis
PROMETHEE	Preference Ranking Organization Methods for Enrichment Evaluations
ROI	return on investment