SCOPE360

Selected empirical evidence on uncertainty, risk and systematic errors in CAPEX decisions

Purpose

This note summarises selected empirical and practitioner evidence showing how risk, uncertainty and decision bias systematically distort large, irreversible capital investment decisions, and how uncertainty and sensitivity analysis help mitigate these failures.

1. Embedded decision analysis in large-scale CAPEX (Chevron)
INFORMS Decision Analysis Society – Practice Award

Chevron is widely cited as a benchmark for the systematic integration of decision analysis, uncertainty modelling and sensitivity analysis into major capital investment decisions, particularly in energy and resource-intensive projects.

Practice evidence shows that embedding uncertainty analysis prior to capital commitment improves risk visibility, strengthens capital allocation discipline and reduces exposure to downside outcomes ignored by deterministic evaluations.

Relevance for CAPEX: demonstrates that uncertainty-based analysis is not academic, but operationally viable and scalable in large, real-world investment environments.

https://www.informs.org/Recognizing-Excellence/Community-Prizes/Decision-Analysis-Society/Decision-Analysis-Practice-Award

2. Systematic bias and optimism in large infrastructure investments

Flyvbjerg, B. (2009). *Survival of the Unfittest*. Oxford Review of Economic Policy.

This paper documents extensive empirical evidence showing that ex-ante cost–benefit analyses of large infrastructure projects systematically underestimate costs, overestimate benefits and downplay risk. Projects that appear strongest on paper frequently exhibit the worst ex-post performance.

The root causes are identified as structural incentives, optimism bias and strategic misrepresentation, rendering traditional cost–benefit and NPV analyses unreliable for major irreversible investments.

Relevance for CAPEX: explains why point estimates and deterministic NPV-based appraisals systematically mislead capital approval decisions in large, irreversible projects.

https://academic.oup.com/oxrep/article-abstract/25/3/344/424009

3. Global sensitivity analysis in investment project evaluation

Peccati, L. & Borgonovo, E. (2006). *Uncertainty and global sensitivity analysis in the evaluation of investment projects*. International Journal of Production Economics.

This study demonstrates how global sensitivity analysis complements uncertainty analysis by identifying which uncertain inputs truly drive project value and risk. It shows that sensitivity rankings differ materially across valuation metrics and that information derived from NPV-based sensitivity cannot be transferred to IRR.

Relevance for CAPEX: supports the use of global sensitivity analysis to focus attention on the variables that materially affect decision outcomes.

https://www.sciencedirect.com/science/article/pii/S0925527305002252

4. CAPEX estimation bias under asymmetric cost distributions

Emhjellen, K. et al. (2002). *Investment cost estimates and investment decisions*. Energy Policy.

This paper shows that common industry practice of reporting median (P50) CAPEX values, rather than expected values, leads to systematic valuation errors when cost distributions are asymmetric. This practice results in acceptance of projects with negative expected NPVs.

The effect is particularly pronounced in oil, energy and capital-intensive industries.

Relevance for CAPEX: demonstrates how standard CAPEX estimation conventions can systematically bias project valuation and lead to incorrect investment approval decisions.

https://www.sciencedirect.com/science/article/pii/S0301421501000659

5. Monte Carlo risk analysis in investment appraisal

Savvides, S. (2012). *Risk analysis in investment appraisal*. Project Appraisal.

This work shows how Monte Carlo–based risk analysis improves interpretation of expected value, downside exposure and decision robustness compared to deterministic appraisal approaches.

It also discusses the limitations of traditional appraisal methods when uncertainty is high and irreversible capital is at stake.

Relevance for CAPEX: provides a methodological foundation for uncertainty-based decision support in capital-intensive investments.

https://doi.org/10.1080/02688867.1994.9726923

Implications for capital investment decisions

Across sectors, empirical evidence shows that large CAPEX decisions fail less due to execution issues than to systematic underestimation of risk, uncertainty and asymmetry at approval stage. Uncertainty and sensitivity analysis directly address this gap by stress-testing assumptions before capital is irreversibly committed.