Aalto-yliopisto
Perustieteiden
korkeakoulu

Robustness evaluation of dynamic maintenance strategies

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15.06.2022

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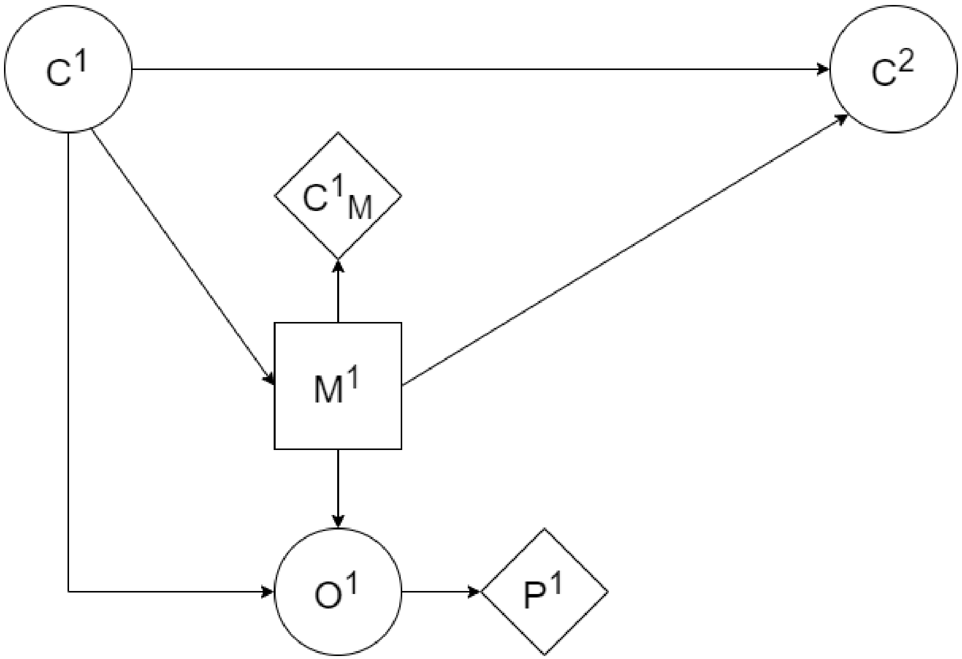
Background

- Maintenance and repair activities consume considerable amounts of resources
- These activities can be modeled and optimized
- We build a multi-periodic decision model with three periods, where the maintenance and repair activities are selected based on external load and the asset condition
  - Asset condition (e.g. poor, fair, good, excellent)
  - External load (e.g. extreme weather conditions) => assets may fail

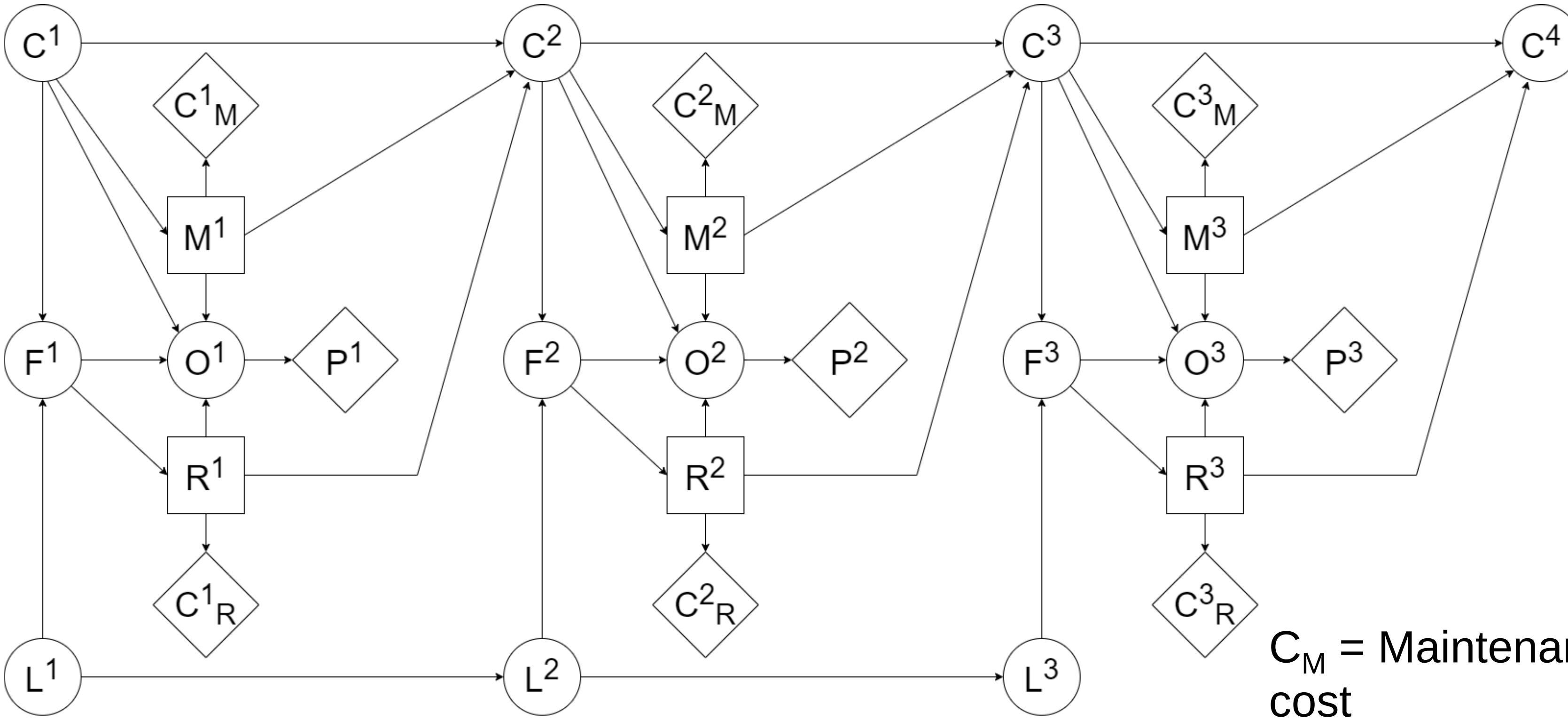
Influence diagrams and decision programming

- Suitable for modeling dynamic decision problems
- Squares represent decisions among discrete alternatives
- Circles represent uncertainties associated with random events
- Both decision- and chance nodes have a finite set of discrete states
- Diamonds represent consequences



C = Condition
M = Maintenance
O = Operational capability
P = Performance
C_M = Maintenance cost

Decision model with three periods and external load



C = Condition
F = Failure

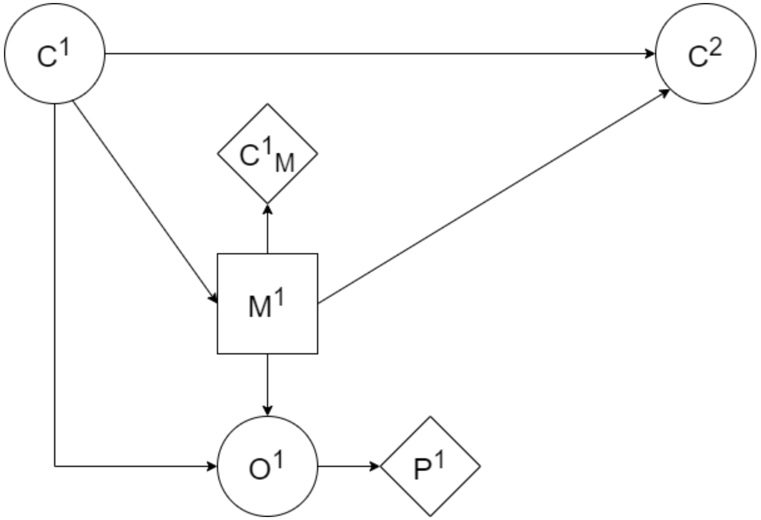
R = Repair
M = Maintenance

O = Operational capability
L = External Load

C_M = Maintenance cost
C_R = Repair cost
P = Performance

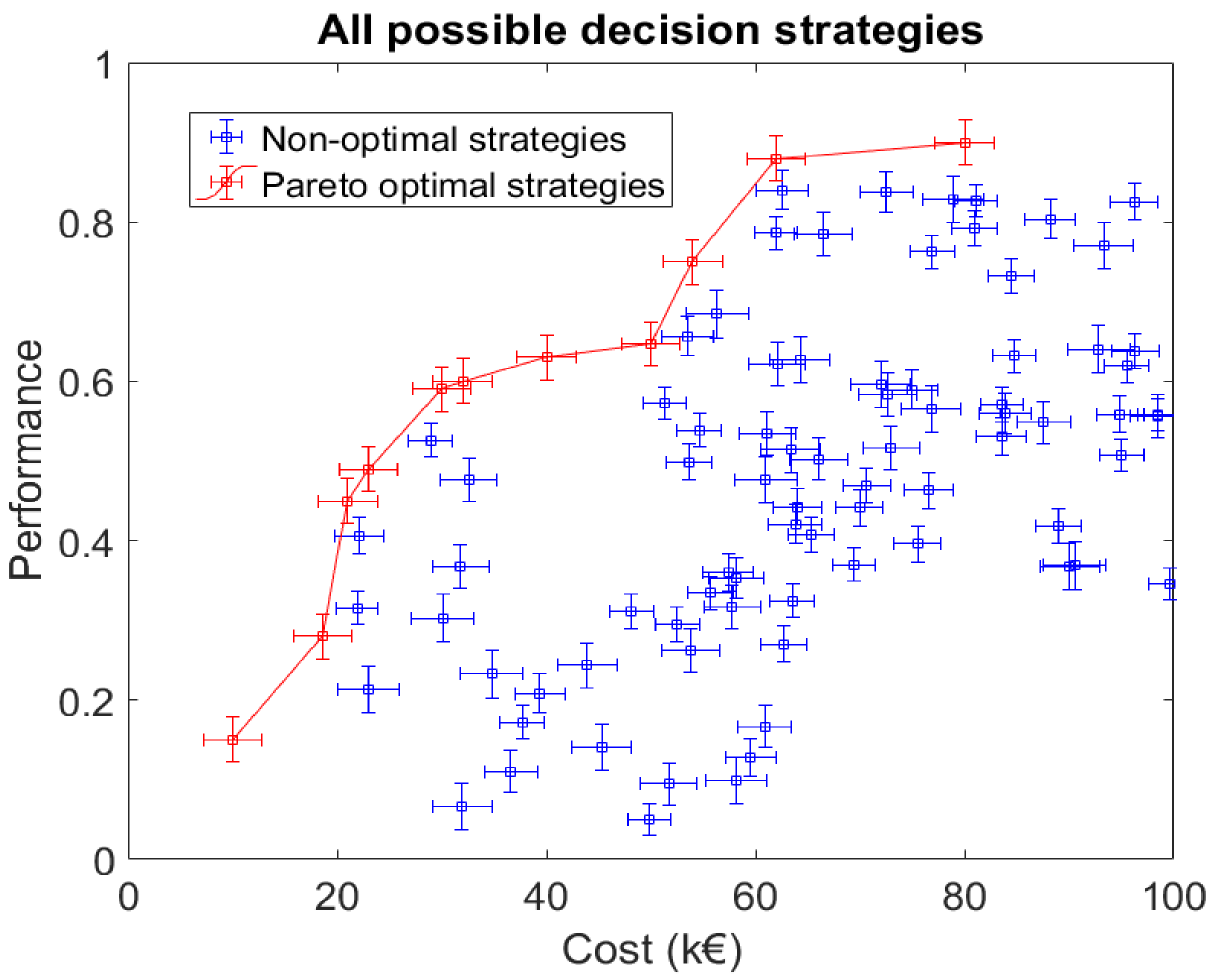
Optimality in decision models

- The results consist of optimal strategies and the expected utilities they imply



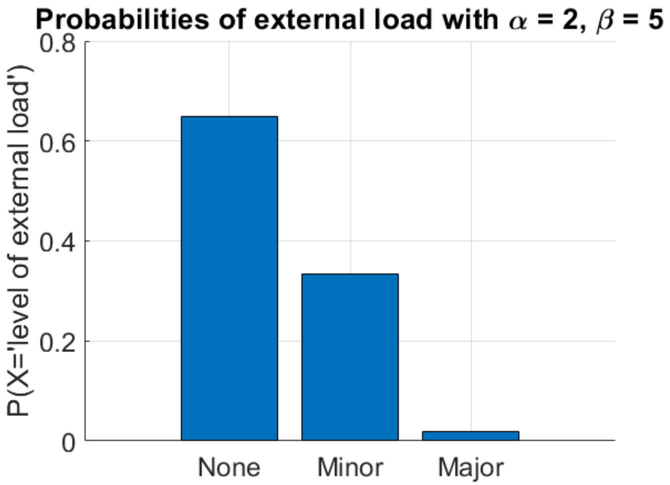
Strategy	Node	Information state	Decision	Performance	Cost (k€)
Z_1	M^1	Bad Good Great	Do not maintain Do not maintain Do not maintain	0,5	0
Z_2	M^1	Bad Good Great	Maintain Maintain Do not maintain	0,9	50

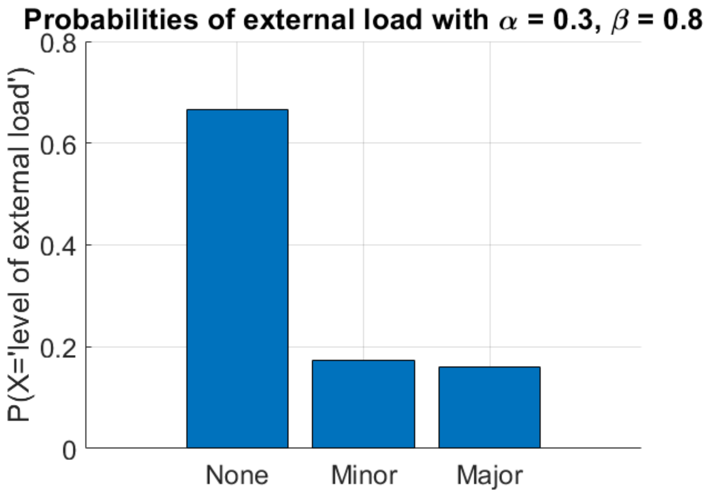
Pareto optimality

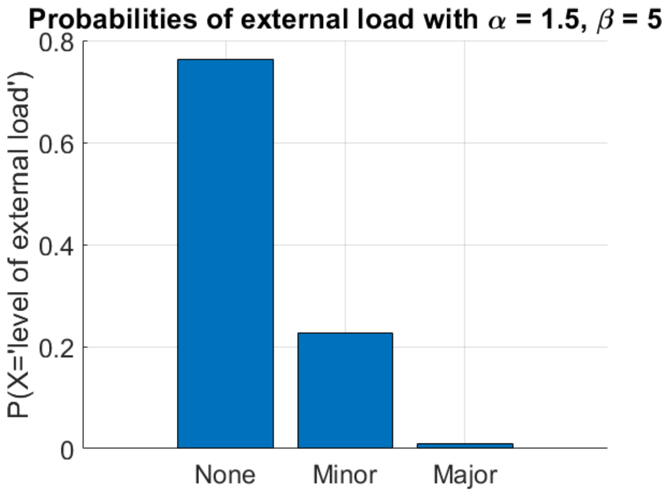


Robustness evaluation

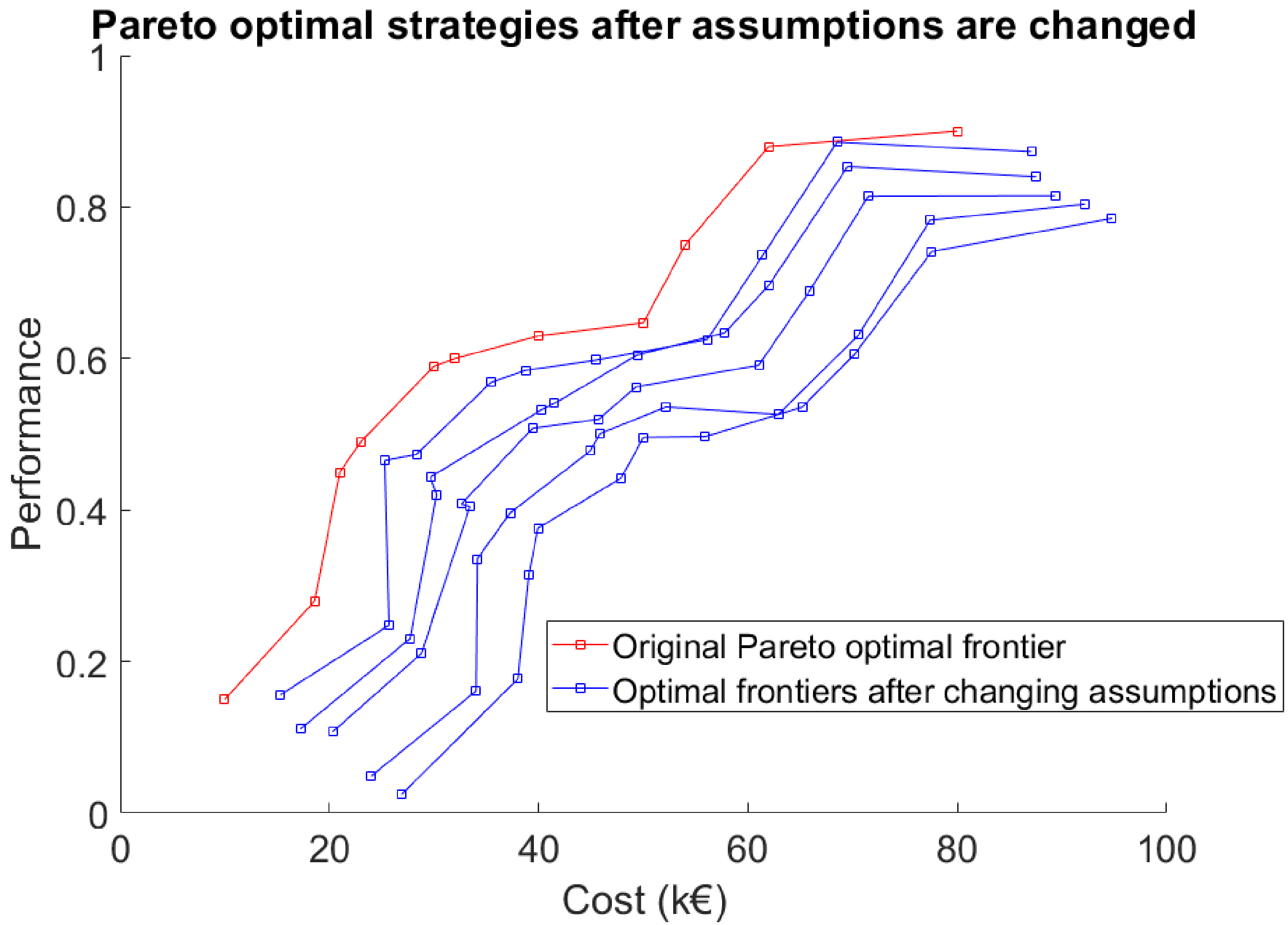
- How do the optimal decision strategies perform when assumptions about numerical parameters do not hold?







Robustness evaluation



Goal

- Find robust strategies which perform relatively well when the numerical parameters are perturbed
- Examine how the relationship between repairs and maintenances affects the robustness of the strategy
- Derive insights
  - For example: Investing 20% more in maintenance causes the sensitivity of the performance with regard to the perturbed parameter values of the external load to be 30% smaller

Tools

- Decision programming
- Julia
- Monte Carlo simulation

Sources

- Salo, A., Andelmin , J., Fabricio, O. (2022). Decision programming for mixed-integer multi-stage optimization under uncertainty. European Journal of Operational Research, 299(2), 550-565.
- Olander, L. (2022). Decision Programming Formulations for Optimal Asset Portfolio Management Under Uncertainty. Master's thesis. School of science, Aalto University.

Schedule

- Presentation of the topic 15.06.2022
- Writing the thesis 06-08/2022
- Presentation of completed thesis 09/2022