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Selecting a portfolio of actions with incomplete and action-dependent scenario probabilities

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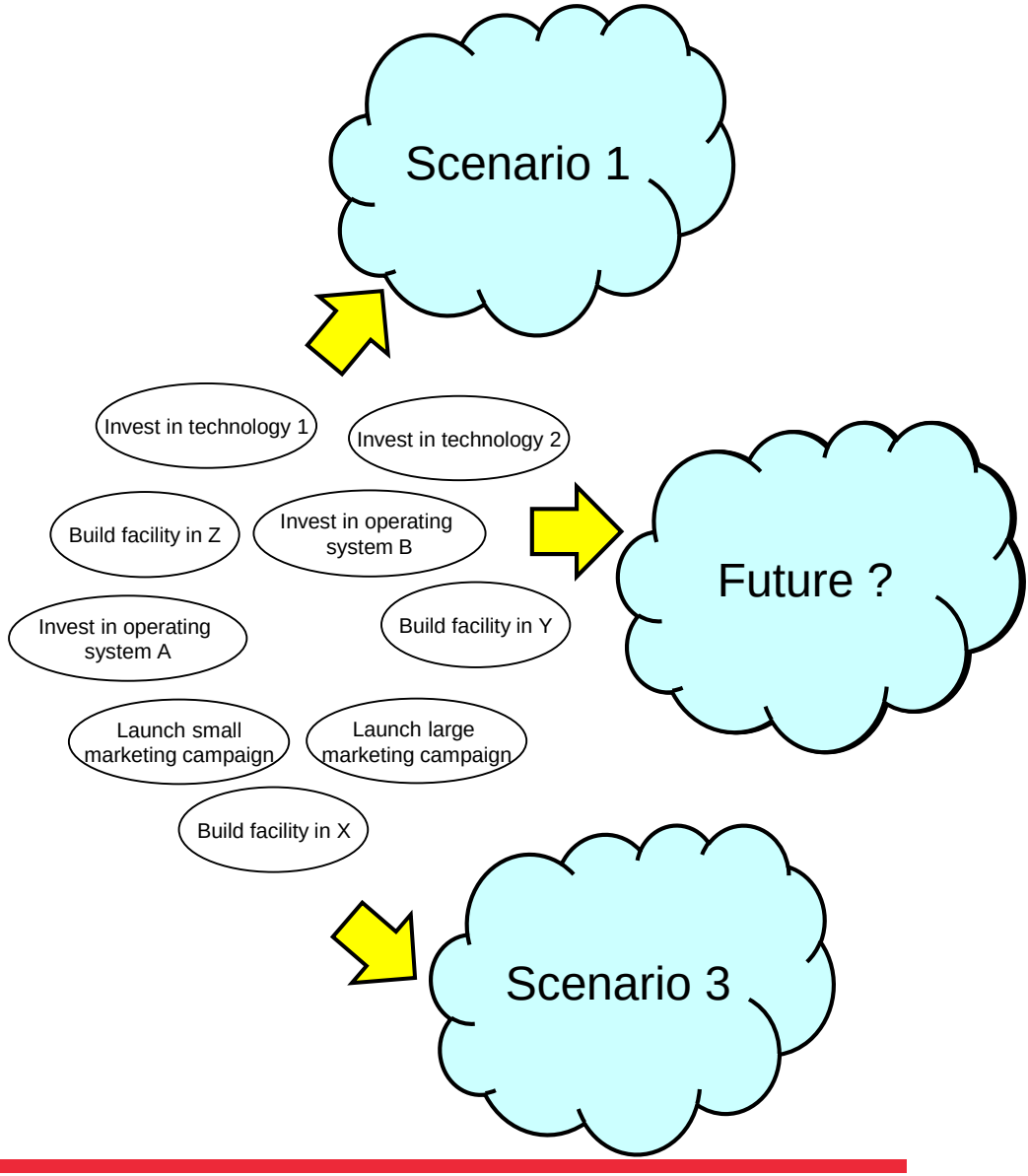
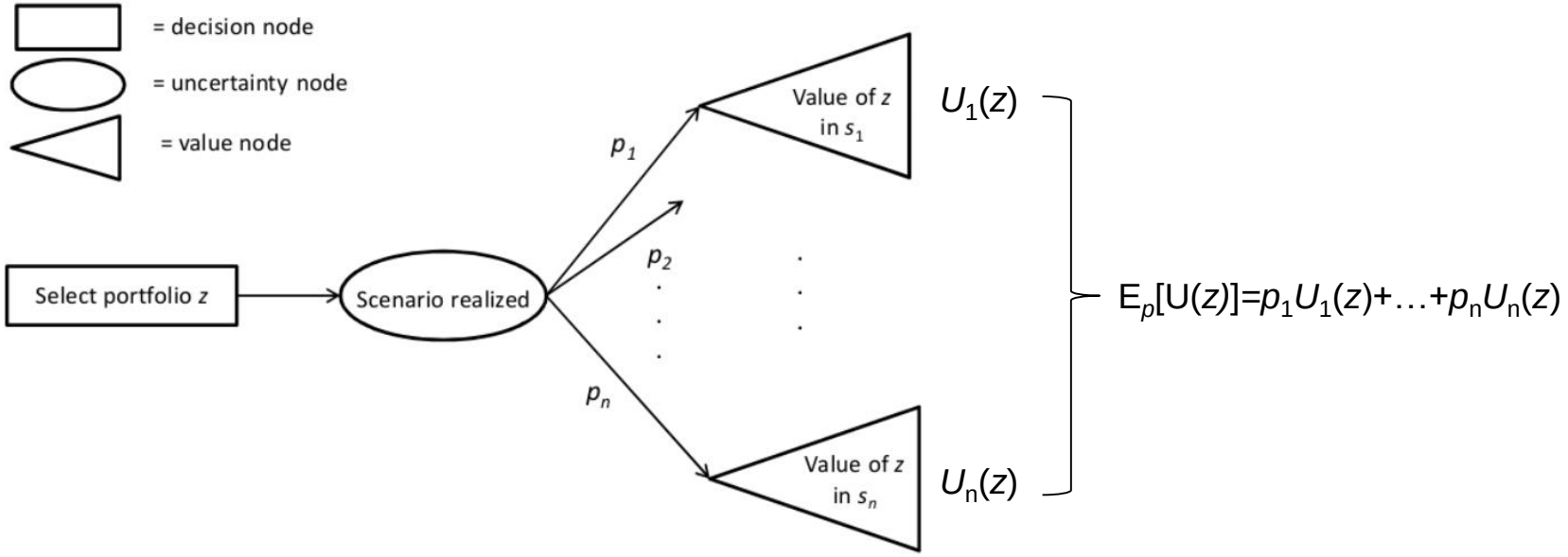
Scenario planning

- The future operational environment of organizations is typically uncertain
  - Different environments call for different strategic actions
- Traditional strategic planning: focus on the most likely future
- Scenario planning: consider a set of plausible futures



Scenario-based action portfolio selection

- Build scenarios $s_1,\ldots,s_n$ to characterize future environments
- Assign probabilities $p_1,\ldots,p_n$ to these scenarios
- Evaluate how available actions perform in these scenarios
- Select the action portfolio z which has the highest expected utility



Scenario-based action portfolio selection

- It may be difficult to obtain precise estimates for scenario probabilities
  - Psychological biases, time constraints etc.

- Actions may affect the scenario probabilities
  - E.g., actions taken to reduce CO_2 emissions affect future climate conditions
  - Neglecting these effects may lead to suboptimal decisions

Incomplete and action-dependent scenario probabilities

- Incomplete probability information
  - ”Scenario 1 is more probable than scenario 2”
  - ”The probability of scenario 3 is between 40% and 60%”
  - Statements define *a set of feasible probabilities*

- Action-dependent probability information
  - ”If either action *A* or *B* is selected, then the probability of scenario 1 is higher than 50%”
  - ”If both of actions *C* and *D* are selected, then the probability of scenario 2 is lower than 20%”
  - Statements define *different probability sets* for different portfolios

Non-dominated portfolios

- Portfolio *z* dominates portfolio *z'*, if
  - $E_p[U(z)] \geq E_p[U(z')]$ for all feasible scenario probabilities $p=[p_1,\ldots p_n]$
  - $E_p[U(z)] > E_p[U(z')]$ for some feasible scenario probabilities p

- A rational DM selects a *non-dominated (ND) portfolio*

- Action-specific recommendations are based on core index (CI)

$$\text{CI of action j} = \frac{\#\text{ of ND portfolios that include j}}{\#\text{ of ND portfolios}}$$

  - CI = 1: action included in all ND portfolios → select
  - CI = 0: action not included in any ND portfolio → reject
  - 0 < CI < 1: action included in some ND portfolios but not all

Example: Selection of R&D portfolio at a high-tech company

- Four scenarios:

Regulation	Low	High
Strong	Scenario 1: The company's technology shares the market with alternative low-cost technologies	Scenario 2: The company's new technology dominates the market
Weak	Scenario 3: Both the company's technology and alternative ones 'tank' in the market	Scenario 4: Alternative low-cost technologies dominate the market

Market demand

Source: Raynor, M.E., X. Leroux. 2004. Strategic flexibility in R&D. *Research Technology Management*, Vol. 47, pp. 27–32.

Example

- Eight available R&D projects (=actions)
  - Projects 1-4 maintain current businesses
  - Projects 5-8 develop new technologies
  - Portfolio must contain at least 25% of both types
  - Project 5 can only be selected if 8 is selected
- Two campaigns (=actions)
  - *Lobbying campaign L* increases the probability of strong regulation
  - *Marketing campaign M* increases the probability of high market demand
- Budget $59M
- Risk neutral decision-maker

Example – projects' values and costs

s_1: Strong regulation, low market demand

s_2: Strong regulation, high market demand

s_3: Weak regulation, low market demand

s_4: Weak regulation, high market demand

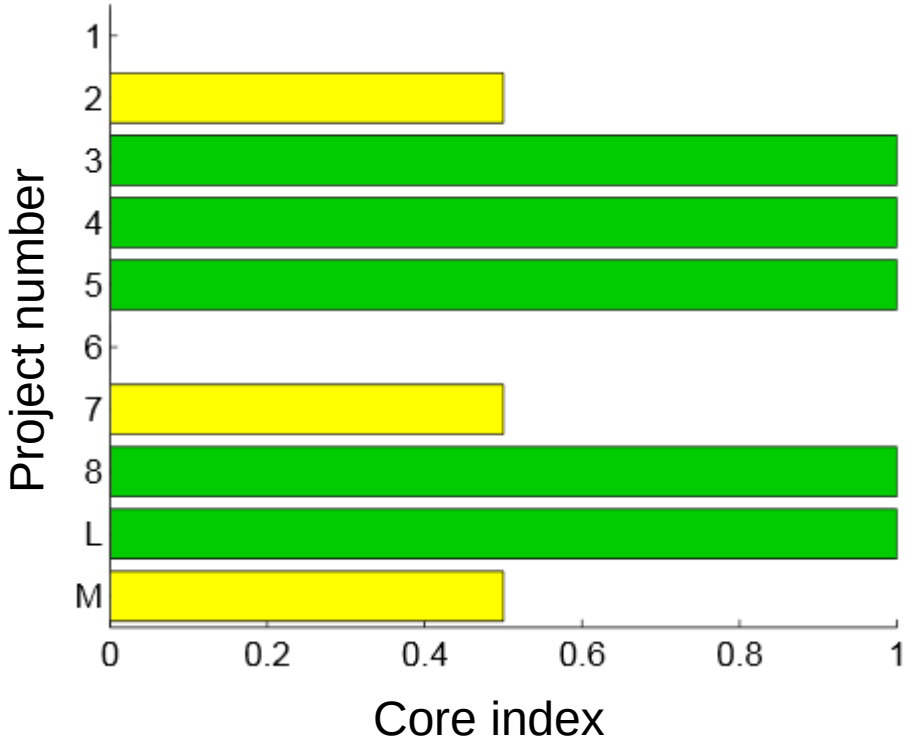
Project	NPV ($M)				Cost ($M)	Average BCR
	s_1	s_2	s_3	s_4		
1	11	52	2	7	15	1.20
2	9	37	2	7	11	1.25
3	12	52	3	6	9	2.03
4	9	33	6	6	7	1.93
5	10	46	4	7	8	2.09
6	12	30	4	9	14	0.98
7	10	47	3	8	14	1.21
8	15	38	5	9	19	0.88
L	0	0	0	0	2	0
M	0	0	0	0	3	0
Optimal portfolio value	58	221	22	38		

Example – scenario probabilities

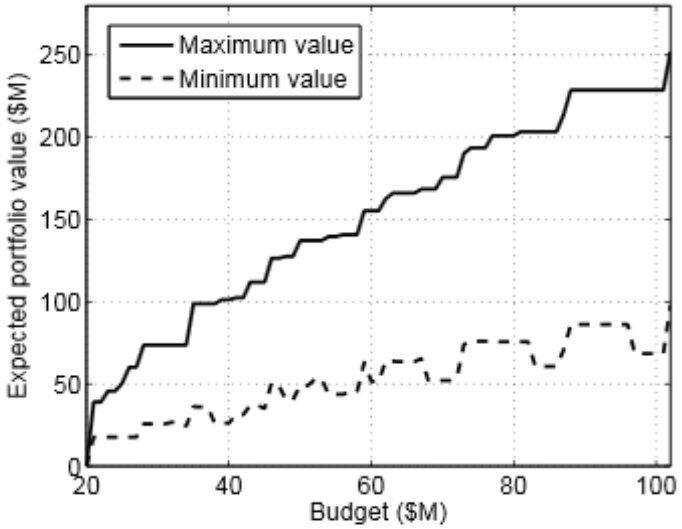
- Probability of strong regulation (s_1 □ s_2) is
  - At least 70%, if the lobbying campaign is started
  - At most 50% otherwise
- Probability of high market demand (s_2 □ s_4) is
  - At least 60%, if the marketing campaign is started
  - At most 50% otherwise
- Probability of each scenario □ 10% regardless of which actions are selected

Results

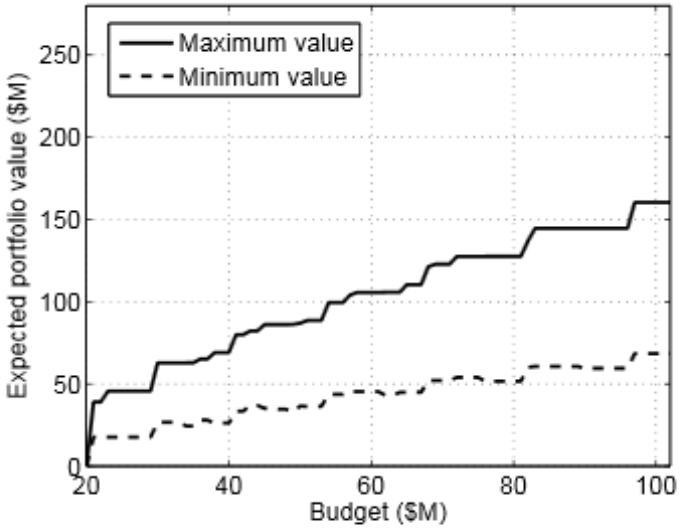
- 373 feasible portfolios
- Two non-dominated portfolios
  - {2,3,4,5,8,L,M}
  - {3,4,5,7,8,L}



Results



(a) Probabilities depend on selected actions



(b) Probabilities do not depend on selected actions

- With $59M budget, the use of action-dependent probability information helps increase
  - the worst-case expected portfolio value by 39%,
  - the best-case expected portfolio value by 47%.

Conclusions

- Model to support the selection of a portfolio of actions when
  - Information about scenario probabilities is incomplete
  - Scenario probabilities may depend on selected actions

- The model helps select portfolios that are
  - *Resilient* in that they perform relatively well across scenarios
  - *Proactive* in that they promote the realization of favorable scenarios

- Decision recommendations can be obtained
  - With fairly loose constraints on scenario probabilities
  - For actions that yield value only indirectly by affecting scenario probabilities