Building resilient and proactive strategies through scenario planning

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Background

- Companies that leverage platform business models have grown dramatically over the past decade
  - Network effects: users attract more users (Facebook, PlayStation...)
  - Efficient matching and asset utilization (eBay, Uber, Airbnb...)
  - Sources of innovation (iOS, Windows...)

- Case study with Finnish companies operating in the steel industry
  - What kinds of business strategies are needed to build a platform ecosystem?
  - How to select a business strategy that is resilient across different scenarios of the future operational environment?
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 strategy development

- 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 combination of actions $z$ (=strategy) which has the highest expected utility

$$E_p[U(z)] = p_1 U_1(z) + \ldots + p_n U_n(z)$$
Scenario-based strategy development

- Precise estimates for scenario probabilities may not be obtained
  - Psychological biases, time constraints etc.
  - Experts’ views may differ
  - The ‘best’ strategy may be sensitive to small changes in scenario probabilities

- Actions may impact scenario probabilities
  - E.g., investments in lobbying for stronger regulation may increase the probability of ‘high regulation’ scenario
  - Neglecting these impacts 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%’
  - Such statements can be modeled by linear constraints that 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%’
  - Statements define *different probability sets* for different strategies

\[
p(z) \in P^1 \quad \text{and} \quad p(z) \in P^2
\]
Non-dominated strategies

- Incomplete probability information → strategies’ expected utilities are intervals

- Strategy $z$ dominates strategy $z'$, if
  - $E_{p(z)}[U(z)] \geq E_{p(z')}[U(z')]$ for all feasible $p(z), p(z')$
  - $E_{p(z)}[U(z)] > E_{p(z')}[U(z')]$ for some feasible $p(z), p(z')$

- A rational decision-maker selects a non-dominated (ND) strategy
Core index

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

Core index of action $j = \frac{\text{# of ND strategies that include } j}{\text{# of ND strategies}}$

- CI = 1: action included in all ND strategies → select
- CI = 0: action not included in any ND strategies → reject
- $0 < \text{CI} < 1$: action included in some ND strategies but not all

Scenario 1
- Invest in operating system A
- Build facility in X
- Invest in operating system B

Scenario 2
- Invest in technology 1
- Build facility in Y
- Large platform investment

Scenario 3
- Invest in technology 2
- Build facility in Z
- Small platform investment
Computation of ND strategies

- Action-dependent probability information divides the feasible strategies into $K$ sets $Z^k$, $k=1,\ldots,K$ such that for all $z \in Z^k$, the set of feasible probabilities $P^k$ is the same.

- Within each $Z^k$, the set of ND strategies $Z^k(ND)$ is equal to the set of Pareto optimal solutions to MOZOLP:

$$v - \max_{z \in Z^k} [z^T X p^1, \ldots, z^T X p^r]$$

where $X$ is the matrix of the actions’ scenario-specific utilities and $\{p^1,\ldots, p^r\}$ is the set of extreme points of $P^k$.

- This MOZOLP can be efficiently solved by a dynamic programming algorithm*


### Average computation time for $Z^k(ND)$ (seconds)

<table>
<thead>
<tr>
<th># of actions</th>
<th># of scenarios</th>
<th>3</th>
<th>5</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td></td>
<td>0.28</td>
<td>1.18</td>
<td>2.66</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>3.06</td>
<td>9.89</td>
<td>20.72</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>11.61</td>
<td>46.62</td>
<td>183.6</td>
</tr>
</tbody>
</table>

### Average # of strategies in $Z^k(ND)$

<table>
<thead>
<tr>
<th># of actions</th>
<th># of scenarios</th>
<th>3</th>
<th>5</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td></td>
<td>27</td>
<td>54</td>
<td>74</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>49</td>
<td>121</td>
<td>180</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>85</td>
<td>220</td>
<td>312</td>
</tr>
</tbody>
</table>
Computation of ND strategies

- To exclude dominated strategies, pairwise dominance checks are carried out between strategies in different sets $Z_k^{(ND)}$, $k=1,\ldots,K$.
Example: Selection of R&D portfolio at a high-tech company

- Four scenarios:
  - **Scenario 1:** The company’s technology shares the market with alternative low-cost technologies.
  - **Scenario 2:** The company’s new technology dominates the market.
  - **Scenario 3:** Both the company’s technology and alternative ones ‘tank’ in the market.
  - **Scenario 4:** Alternative low-cost technologies dominate the market.

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Strong</th>
<th>Weak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market demand</strong></td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

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

- Investments in 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

<table>
<thead>
<tr>
<th>Project</th>
<th>NPV ($M)</th>
<th>Cost ($M)</th>
<th>Average BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>s₁: Strong regulation, low market demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>2</td>
<td>7</td>
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<tr>
<td>3</td>
<td>12</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>s₂: Strong regulation, high market demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>s₃: Weak regulation, low market demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>s₄: Weak regulation, high market demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>M</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Optimal portfolio value</td>
<td>58</td>
<td>221</td>
<td>22</td>
</tr>
</tbody>
</table>
Example: probability information

- Probability of strong regulation \((s_1 \cup s_2)\) is
  - At least 70%, if the company invests in lobbying campaign \(L\)
  - At most 50% otherwise

- Probability of high market demand \((s_2 \cup s_4)\) is
  - At least 60%, if the company invests in marketing campaign \(M\)
  - At most 50% otherwise

- Probability of each scenario \(\geq 10\%\) 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\}
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 combination of actions (=strategy), when
  - Information about scenario probabilities is incomplete
  - Scenario probabilities may depend on selected actions

- The model helps select a strategy that is
  - *Resilient* in that it performs relatively well across scenarios
  - *Proactive* in that it promotes 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
Case study

- Done: identification of plausible scenarios for future operational environment

- Next steps:
  - Listing of actions by decision-makers
  - Elicitation of parameters
    - Actions’ values in each scenario
    - Scenario probability information
  - Computation of resilient and proactive strategies
  - Dissemination and discussion of the results