Methodological and behavioural challenges in scenario analysis and policy assessment

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“You can't connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future. This approach has never let me down, and it has made all the difference in my life.”

– Steve Jobs
On 8 April 2020, the Prime Minister’s Office appointed a working group tasked with preparing a plan for Finland’s way out of the COVID-19 crisis and deciding on measures to deal with its aftermath.

With regard to the first task of the mandate, the preparation group will report by 1 May on measures to limit the economic and social damage in the immediate crisis stage and on how to move away from the measures now decided in a timely manner.

With regard to the second task, the preparation group will report by 31 May on the post-crisis measures and how to prepare for their introduction in the various sectors of society.

The preparation group consists of the Permanent Secretaries of the ministries, with Martti Hetemäki from the Ministry of Finance as Chair and Kirsu Varhila from the Ministry of Social Affairs and Health as Vice-Chair. The group is supported by a secretariat whose members are appointed by the ministries.

To support the preparation group, a scientific panel will be set up consisting of researchers/experts from different fields of expertise, such as social policy, education policy and economic policy as well as the environmental and climate sciences. The proposal for the experts to be invited to the panel will be prepared by representatives from the scientific community (Universities Finland UNIFI, the Consortium of State Research Institutions Tulanet and the Finnish Academy of Science and Letters). During its work, the preparation group will consult with representatives of the business community, municipalities, civil society organisations and environmental organisations on a broad basis.
COVID-19 study review

The COVID-19 research review brings together the latest research results from the world and Finland related to the coronary crisis in a close and informative manner for the use of preparers and decision-makers.

The aim of the review is to strengthen the transmission of current research information to decision-makers and to create a perspective on the latest research.

The research review is divided into eleven areas, from which about five significant new studies and research results are brought to the review:

1. COVID-19 infection,
2. Impact of restrictive measures on the spread of the epidemic,
3. The effects of the pandemic on the well-being of the population,
4. Economy and business,
5. Inequality,
6. Education and learning,
7. Technology and innovation,
8. Environment and sustainable development,
9. International relations, EU and security,
10. People and behavior as well
11. Resilience and anticipation.

https://tietokayttoon.fi/covid-19-tutkimuskatsaukset
Government Foresight Group

The Government Foresight Group lends support to national foresight work, joint foresight processes and the development of national foresight activities. Its key objective is to help foresight activities and foresight-based information forge a connection with decision-making processes. A Secretariat assigned to the Prime Minister’s Office performs preparatory work and aids the Government Foresight Group’s work.

The composition of the Government Foresight Group 2020–2023

Secretary Henrik Haapajärvi, Prime Minister’s Office, chairman
Chief Senior Specialist Jaana Tapanainen-Thiess, Prime Minister’s Office, Secretary General
Professor Toni Ahlqvist, Finland Futures Research Centre, University of Turku
University Lecturer Jenni Airaksinen, Faculty of Management, Tampere university
Committee Counsel Olli Hietanen, Committee for the Future, Parliament of Finland
Academy Secretary Jaakko Kuosmanen, Finnish Academy of Science and Letters
Development Director Petri Räsänen, Ministry of Economic Affairs and Employment

**Professor Ahti Salo, Aalto University**
Head of EU Affairs Leena Sarvaranta, VTT Technical Research Centre of Finland
Secretary General Vesa Valtonen, Secretariat of the Security Committee
Director Katri Vataja, Sitra

Permanent expert:
Kaisa Oksanen, Senior Adviser, Prime Minister’s Office
Pillars of systems and operations research

\[
\begin{align*}
\min \quad & \sum_{i \in R} \sum_{j \in D_i} c_{ij} x_{ij} + \sum_{k \in R} M y_k \\
\text{s.t.} \quad & \sum_{i \in R_k} \sum_{j \in D_i} x_{ij} + y_k = 1, \\
& \sum_{i \in R} x_{ij} \leq 1,
\end{align*}
\]
Challenges for model-assisted policy advice

- Will people obey restrictions?
- How to address trade-offs between sectors?
- Which model is to be trusted?
- What impacts are there beyond model scope?
- How does the virus spread?
- What properties do new variants have?
- How to address trade-offs between sectors?
Characteristics of wicked problems

1) They lack a definitive formulation.

2) They have no stopping rule—constraints on time or resources or the perception of the ‘goodness’ of the current resolution determines when work is terminated.

3) Resolutions of wicked problems are not true or false – they can only be judged as ‘good’, ‘bad’, ‘better’ or ‘satisfactory’.

4) There is no immediate or ultimate test of a resolution of a wicked problem - the future repercussions of the resolution may be unforeseen and unintended.

5) Every resolution is a ‘one shot’ operation with significant consequences, precluding the ‘trial and error’ approach.

Characteristics of wicked problems (cont.)

6) It is **impossible to enumerate** an exhaustive set of potential solutions.

7) Every wicked problem is **unique**.

8) Every wicked problem is the **symptom of another problem**.

9) The choice of **explanation** of the problem and hence its resolution **depends on the analyst’s world view**.

10) Decision makers are held responsible for the consequences of the actions they take in attempting to resolve a wicked problem.

Rationales for scenario analysis

- In the **Volatile, Uncertain, Complex, Ambiguous** world (VUCA\(^1\)) forecasts do not suffice
- It is therefore better to prepare for **alternative futures**
- Elaborating these futures as **scenarios** broadens perceptions and serves to inform decisions; but
  - ... which scenarios out of the many possible should be built?
  - ... how well can scenarios produced by others be internalised?
  - ... what kinds of scenarios and scenario processes are “good”? \(^1\)

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Evolution of foresight methodologies (simplified)

- 1960: Oil crisis
- 1970: Long range planning
- 1980: Scenario analysis
- 1990: Cross-impact methods
- 2000: Large-scale European Delphi studies
- 2010: Industrial clusters
- 2020: Artificial intelligence

Forrester’s system dynamics
Technology mining
Social media platforms
What is a “scenario”?

❑ “A hypothetical **sequence** of events constructed for the purpose of focusing attention on **causal processes** and **decision points**”
  (Kahn and Wiener, 1967)

❑ “A quantitative or qualitative **picture** of a given organisation or group, developed within the framework of a set of specified assumptions”
  (MacNulty, 1977)

❑ “A **description** of a possible **future state** of an organisation's **environment** considering possible developments of relevant interdependent factors in the environment”
  (Brauers and Weber, 1988)
What is a “scenario”? (cont.)

- “An internally consistent **view of what the future** might turn out to be – not a forecast, but one future outcome”  
  (Porter, 1985)

- “A **tool for ordering one’s perceptions** about alternative future environments in which one’s decisions might be played out”  
  (Schwartz, 1991)

- “That part of strategic planning which relates to the **tools and technologies** for managing the uncertainties of the future”  
  (Ringland, 1998)
What can scenarios be used for?

1) Connecting scenarios to a purpose.
2) Generating strategies.
3) Creating and stress testing strategic plans.
4) Testing decisions and options.
5) Assessing the financial benefits of scenarios.
6) Modelling financials with scenarios.
7) Developing scenario signals and critical uncertainty dashboards.
Typical phases of a scenario process

Structuring the development of scenarios

1. What are the key uncertainty factors?
2. What are the possible outcomes of these uncertainty factors?
3. Which combinations of outcomes (=scenarios) are plausible?
4. What would the salient features of the future be in these scenarios?
5. What are the implications for choosing strategic actions?
   - Which actions lead to better consequences in different scenarios?
   - Are there robust strategies which perform well across all scenarios?
   - Are there proactive strategies which impact how likely the scenarios are?

<table>
<thead>
<tr>
<th>Type of stakeholder</th>
<th>Contribution</th>
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<tbody>
<tr>
<td>Experts</td>
<td>Expertise in the topic</td>
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<tr>
<td>Stakeholder representatives</td>
<td>Viewpoints from representatives of organizations or groups with a stake in the outcome of the scenario process</td>
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<tr>
<td>Personal stakeholders</td>
<td>Viewpoints from people with a stake in the outcome of the scenario process</td>
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<td>Remarkable people</td>
<td>Viewpoints from people with experience, knowledge, creativity, inventiveness</td>
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<tr>
<td>Citizens</td>
<td>Representative viewpoints of the general public with or without a direct stake in the outcome of the scenario process</td>
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<td>Method for stakeholder inclusion</td>
<td>Key tensions and challenges</td>
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<td>Workshops</td>
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<td>Calendar and availability issues</td>
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<td>Asymmetries in participants’ engagement</td>
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<td>Interviews</td>
<td>Limited knowledge sharing among participants</td>
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<td>Surveys/Delphi</td>
<td>Low response rates</td>
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<td>Fatigue before completing questionnaire</td>
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<td></td>
<td>Limited knowledge sharing among participants</td>
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Biases of cognition, reasoning and behaviour

- Confirmation bias – acknowledging only confirming information
- Knowledge bias – ignoring facts one does not understand
- Focusing bias – putting too much emphasis on a single factor
- Anchoring bias – over-emphasizing the first received piece of information
- Ideological bias – extrapolating unduly one’s implicit values
- Tactical bias – ignoring consciously evidence to further one’s objective
- Funding bias – supporting the interests of one’s financial sponsor
- Implicit biases – expressing automatic prejudiced judgments
- Blind spot bias – not being cognizant of one’s own biases
- Media biases – influencing the selection of what is broadcast

Illustrative uncertainty factors for an electricity utility

<table>
<thead>
<tr>
<th>A. Energy regulation’s focus</th>
<th>B. Electricity price</th>
<th>C. Competitive field</th>
<th>D. Customer churn rate</th>
<th>E. Technology &amp; digitalization</th>
<th>F. Finnish economy</th>
</tr>
</thead>
</table>

Curse of dimensionality

- The number of alternative scenarios can be enormous!
  - $4 \times 4 \times 4 \times 3 \times 3 \times 3 = 1728$ scenarios for the energy utility
  - 10 uncertainty factors with 4 levels for each $\Rightarrow 4^{10} = 1048576$ scenarios

- The “realized” future will most likely differ from that in any scenario

- Scenario developers should not be faulted for “having missed it”

- Quality requirements on scenario content
  - **Coherence**: Scenarios are formulated within a sound methodological framework (e.g., probabilistic decision theory supports integration with statistical analyses, data mining and use of structured expert judgements)
  - **Consistency**: Scenarios do not exhibit logical inconsistencies
  - **Comprehensiveness**: Scenarios cover all relevant futures “well enough”

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## Assessment of (in)consistencies

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Explanation</th>
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<tr>
<td>-3</td>
<td>Strongly inconsistent: It is very unlikely that the levels occur at the same time</td>
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<tr>
<td>-2</td>
<td>Inconsistent: It is moderately unlikely that the levels occur simultaneously</td>
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<tr>
<td>-1</td>
<td>Slightly inconsistent: The levels hinder each other, but they can occur simultaneously</td>
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<tr>
<td>0</td>
<td>Independent: The levels occur independently; they have no direct relation</td>
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<td>1</td>
<td>Slightly consistent: The occurrence of one level supports the occurrence of the other</td>
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<tr>
<td>2</td>
<td>Consistent: The occurrence of a level strongly supports the other</td>
</tr>
<tr>
<td>3</td>
<td>Strongly consistent: The occurrence of a level induces the other</td>
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### Competitive field
1. Traditional: private & municipal
2. Consolidation
3. International competitive field
4. New external players

### Customer churn rate
1. Low, under 8%/year
2. Moderate, 9-14%/year
3. High, over 15%/year

### Technology & digitalization
1. Digital evolution
2. Fast digitalization
3. Digital revolution

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Constructing Scenarios Using Cross-Impact Balances

Since its publication in 2006, Cross-Impact Balances (CIB) has established itself internationally, above all, as a method for the systematic construction of qualitative and semiquantitative scenarios. The special feature of the CIB is that it uses qualitative knowledge about the influence relationships between scenario factors using an algorithmic approach, thus making complexity treatable even if the topic under investigation is described in whole or in substantial parts by qualitative knowledge.

In the CIB approach, future developments and their interaction are interpreted as a qualitative network of influences. Qualitative networks are characterized by the fact that each node of the network can only assume a limited number of discrete, qualitatively described states. The arrows between the nodes stand for a matrix that indicates which state of the source node promotes or inhibits which state of the target node. As a result of the mutual promotion and inhibition between the nodes, 'consistent network configurations' emerge. Each of them forms a self-stabilizing network of node states.

For scenario analysis, the most important factors of the system under investigation are defined as the nodes of the network. The main future alternatives for the factors (typically 2-4) are assigned to the nodes as possible node states. Qualitative findings on the promoting or inhibiting influences between the various future developments are collected and their strengths are assessed on an integer scale (e.g., from -3...+3). Together, these data form a 'cross-impact matrix' and the CIB balance algorithm can be used to calculate consistent scenarios for the future of the system. This procedure is demonstrated on the 'Method' page with a simple example.

https://www.cross-impact.org/english/CIB_e.htm
Cross-Impact Balances (CIB)

- Stronger emphasis on causality
- Choose consistent scenarios such that the sum of cross-impact terms for the selected levels of uncertainty factors is maximized for these levels level
- This matrix is not consistent!

Posiva applies to operate used fuel disposal facilities

05 January 2022

Finnish radioactive waste management company Posiva Oy has submitted its application for an operating licence for the used fuel encapsulation plant and final disposal facility currently under construction at Olkiluoto. The repository - the first in the world for used fuel - is expected to begin operations in the mid-2020s.

Edoardo Tosoni, 1,2,* Ahti Salo, 1 and Enrico Zio 2,3

A major challenge in scenario analysis for the safety assessment of nuclear waste repositories pertains to the comprehensiveness of the set of scenarios selected for assessing the safety of the repository. Motivated by this challenge, we discuss the aspects of scenario analysis relevant to comprehensiveness. Specifically, we note that (1) it is necessary to make it clear why scenarios usually focus on a restricted set of features, events, and processes; (2) there is not yet consensus on the interpretation of comprehensiveness for guiding the generation of scenarios; and (3) there is a need for sound approaches to the treatment of epistemic uncertainties.
Cross-Impact Balances (CIB) is not coherent!

- It is possible that **none** of the scenarios in CIB is consistent\(^1\)

- Yet **something** will surely happen!

Cross-impact analysis is widely employed to inform management and policy decisions based on the formulation of scenarios, defined as combinations of outcomes of relevant uncertainty factors. In this paper, we argue that the use of nonprobabilistic variants of cross-impact analysis is problematic in the context of risk assessment where the usual aim is to produce conservative risk estimates which may exceed but are not smaller than the actual risk level.
Decision Support

Scenario-based portfolio model for building robust and proactive strategies

Eeva Vilkkumaa\textsuperscript{a,}, Juuso Liesjö\textsuperscript{a}, Ahti Salo\textsuperscript{b}, Leena Ilmola-Sheppard\textsuperscript{c}

\textsuperscript{a} Department of Information and Service Economy, Aalto University School of Business, P.O. Box 21220, Aalto 00076, Finland
\textsuperscript{b} Department of Mathematics and Systems Analysis, Aalto University School of Science, P.O. Box 11100, Aalto 00076, Finland
\textsuperscript{c} International Institute for Applied Systems Analysis, Schlossplatz 1, Laxenburg A-2361, Austria

Decision Support

Identifying and visualizing a diverse set of plausible scenarios for strategic planning

Teemu Seeve\textsuperscript{a}, Eeva Vilkkumaa

Department of Information and Service Management, Aalto University School of Business, P.O. Box 21220, Aalto FI-00076, Finland
Consistency of scenario $s$

$$\tilde{c}(s) = \frac{2}{J(J-1)} \sum_{j_1=1}^{J-1} \sum_{j_2=j_1+1}^{J} c_{j_1 j_2}(m_{j_1}, m_{j_2})$$
Scenarios for the National Emergency Supply Organization (NESO)

- NESO maintains and develops the security of supply in Finland
- National Emergency Supply Agency plans measures related to developing and maintaining security of supply
- National Emergency Supply Council assesses and reviews the general state of security of supply
- NESO sectors consist of public authorities, associations and other significant operators who steer, coordinate, and monitor preparedness in their respective security of supply fields.
- NESO pools comprise companies and businesses

### Uncertainty factors and their levels

<table>
<thead>
<tr>
<th>A. Globalization &amp; int. relations</th>
<th>B. Geopolitical focus points</th>
<th>C. Security situation</th>
<th>D. Finland’s role in int. politics</th>
<th>E. Resources &amp; pop. movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Slower &amp; safer globalisation</td>
<td>1. Traditional industrial nations</td>
<td>1. Territorial conflicts</td>
<td>1. Impartial &amp; neutral Finland</td>
<td>1. Pronounced regional resource scarcity</td>
</tr>
<tr>
<td>2. Fast market-driven globalisation</td>
<td>2. Focus shifts to market-driven East</td>
<td>2. Conflicts related to (hybrid) influence</td>
<td>2. Finland allied at the European level</td>
<td>2. Declined availability of resources</td>
</tr>
</tbody>
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<tr>
<th>F. Global data openness &amp; security</th>
<th>G. The global economy</th>
<th>H. Development of Europe</th>
<th>I. Smart systems &amp; machines</th>
<th>J. Economic structure &amp; work</th>
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### Cross-impacts matrix

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... (Table continues)...

**Notes:**
- The matrix represents cross-impacts among different categories. Each entry indicates the impact of one category on another.
- The values in the matrix are relational impacts, possibly indicating positive or negative effects.
- The matrix is extensive, covering multiple dimensions and categories, providing a comprehensive view of the cross-impacts.
- Generate a **diverse** set of scenarios such that all levels of uncertainty factors are represented.
1. Global interdependency

The financial crisis faced by developing countries will expose the weaknesses in the economic systems of leading developing countries, which will strengthen the position of the West as a stable safe haven. The rising costs of conflicts and disasters will drive nations towards closer cooperation. The role of international institutions will be strengthened. Applications based on blockchain technology will create new operating models and increase trust.

International conflicts and migration will be brought under partial control and internal cooperation within the EU will increase. The role of EU member states in NATO will grow and Finland will also join NATO. International regulation will increase and environmental and climate policies will become stricter, with western countries driving the establishment of international agreements. In China, however, social problems will increase, and the growth of the global economy will slow down.

Globalisation will slow down and become more stable and regulated. As part of this trend, regulation will also extend to cover digital trust platforms and transactions in the sharing economy. Highly educated people from Asia will move to western countries in search of a higher standard of living, clean air and a democratic societal model. The EU’s role in global politics will increase.
Deteriorating climate conditions and escalating armed conflicts will result in unprecedented population movements and even mass migrations from Eastern Africa and the Middle East to Europe, including Finland. Many nations will close themselves off as a result of nationalistic and protectionist thinking, and withdrawals from international agreements will become more commonplace. Conflicts in the Middle East, North Korea and Eastern Ukraine will escalate.

The world will fall into conflicts and an age of power politics, while actions that threaten the sovereignty of individual nations will increase. Defence alliances will divide nations into different camps, and Finland will also join NATO. Mass migrations will increase cultural collisions, which will serve as a platform for widespread and organised terrorism. The EU will be overshadowed by the defence alliances and by national interests. Sea traffic in the Baltic Sea will become more difficult, which will cause problems in the region and hamper local trade and energy supply operations.

The security policy situation and cyber risks will reduce information sharing and cooperation between nations. The Baltic region, the Arctic region and central logistical routes will become arenas for power politics. A space arms race will start up.
3. Blocification and hybrid influence

Politics based on national interests will weaken international cooperation and the power of global agreements will be reduced. The definition of war will become blurred and cyber attacks will increase. Nations will realise the actual risks of hybrid influence as radical hybrid operations start coming to light.

The world will be reorganised into competing alliances, or blocs. Social, economic and value-related differences between these blocs will increase significantly. Security measures related to cyber risks will be strengthened and critical ICT systems will be isolated to only operate within individual blocs and national borders. The EU will focus on strengthening the internal market and developing a hybrid defence alliance.

Information-based influence will deteriorate people’s trust in institutions and blur the elements that hold societies together. The trust, characteristic of the early 21st century, in information, nations, companies and information systems will come to be considered naive. The blocs and/or nations will develop their own, separate and internal systems for controlling information, preventing external influence and increasing security.
Scenario development is a collective exercise

- How does the virus spread?
- Will people obey restrictions?
- Which model is to be trusted?
- What properties do new variants have?
- What impacts are there beyond model scope?
- How to address trade-offs between sectors?

There is a space for collaborative risk management.
Improving the quality of scenario processes

- **Explorativeness**: To enable thinking of the unprecedented, the process must be sufficiently explorative.

- **Trustworthiness**: To establish trust in the developed scenarios, the process must be transparent and consensus supporting.

- **Efficiency**: To develop scenarios in a timely and efficient manner, the process must be well structured.

- **Accessibility**: To ensure that the stakeholders can contribute their best expertise, the process should not push the stakeholders too far from their capacity.

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Identifying risks is one of the most challenging steps of risk management. Once you have collaboratively identified and assessed key risks, only then is it possible to effectively manage them and respond.

Inclus originated from complex and sensitive peace mediation processes conducted by Nobel Peace Prize laureate and President Martti Ahtisaari’s Crisis Management Initiative (CMI).

Inclus specializes in building common understanding: our tools help to identify, understand, visualize and manage your risks across key organizational processes. Inclus’ expertise stems from peace mediation, where we have constructed solutions in 15 of the world’s most difficult conflict areas. The methodology behind Inclus has been developed in collaboration with Aalto University's Systems Analysis Laboratory.
PARTICIPATORY APPROACHES TO FORESIGHT AND PRIORITY-SETTING IN INNOVATION NETWORKS

Ville Brummer

Dissertation for the degree of Doctor of Science in Technology to be presented with due permission of the Faculty of Information and Natural Sciences for public examination and debate in Auditorium E at Aalto University School of Science and Technology (Espoo, Finland) on the 23rd of June, 2010, at 12 noon.
Methodological challenges

1) **Clarifying concepts:** Well-defined and jointly understood concepts are crucial for avoiding ‘wishy-washiness’.

2) **Assessing interdependencies:** Systematic measurement scales are needed in elicitation, but they should be calibrated.

3) **Ensuring coherence in modelling dynamics:** Causal and correlations are often confused (“eating ice-cream does not make the sun shine”).

4) **Addressing the combinatorial explosion:** Not all futures can be fully elaborated ➔ Methods may prove helpful
Behavioural challenges

1) **Remaining unaware of cognitive biases:** Self-diagnostics has its limitations whilst external criticisms may be resented.

2) **Falling prey to the “grouphink” phenomenon:** There may be a useful role for the “devil’s advocate” or commissioning independent studies.

3) **Generating generalizable knowledge:** The contexts of real-life strategic planning vary hugely – Are the findings of generally valid?

4) **Making rigorous contributions in high-stake high-pressure situations:** In the midst of crises, there are few possibilities for organizing reflective research processes in parallel.
Thoughts on policy assessment

- Systematic support for scenario generation is needed due to
  1. cognitive biases and 2. the large number of possible futures

- Strategies can impact 1. consequences within different scenarios and
  2. the likelihood with which scenarios occur

- In safety-critical systems, no scenarios should be forgotten\(^1\)

\[
\text{Risk}(a) = \sum_{s \in S} \text{Prob}(s, a) \times \text{Cons}(s, a)
\]

- Later decision points and resolution of uncertainties in multi-stage
  problems can be addressed through scenario paths\(^2\)

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