Foresight and Horizon Scanning

Ahti Salo

Systems Analysis Laboratory
Dept of Mathematics and Systems Analysis
Aalto University School of Science
ahti.salo@aalto.fi

Ahti Salo

Professor
Doctor of Technology, Vice Head of Department, Vice Dean of Aalto SCI, research and partner relationships

Professor Salo has worked extensively on the development of decision analytic methods and their uses in resource allocation, innovation management, risk management, technology foresight, and efficiency analysis. He has published widely in leading international journals (including Management Science and Operations Research) and received awards for his research from the Decision Analysis Society of the Institute for Operations Research and the Management Sciences (INFORMS). He is the Editor-in-Chief of the EURO Journal on Decision Processes and on the Editorial Boards of Decision Analysis and five other refereed journals. Professor Salo has directed a broad range of basic and applied research projects funded by leading industrial firms, industrial federations, and funding agencies. He has been a visiting professor at the London Business School, Université Paris-Dauphine and the University of Vienna. In 2010-11, he was the President of the Finnish Operations Research Society (FORS) and served as the European and Middle East representative of the International Activities Committee of INFORMS. He is a jury member of the EDDA 2015 Doctoral Dissertation Award of the Association of European Operational Research Societies (EURO). He has been on the Board of the Association of Parliament Members and Researchers (Tutkas) since 1999.

http://sal.aalto.fi/ahti

Selected engagements

- First technology assessment report for the Futures Committee of the Finnish Parliament (Salo and Kuusi, 2001)

- Mid-term evaluation of the national research and technology programmes in electronics and telecommunication (Salo and Salmenkaita, 2004)

- National foresight study "FinnSight 2015" for the Finnish Government (Salo, Brummer, Könnölä, 2009)

- Presently member of
  ❶ Advisory Group on Foresight, Finnish Prime Minister's Office
  ❷ Expert Group on Strategic Foresight for Research and Innovation Policies in Horizon 2020, EU Directorate-General Research and Innovation

Preliminaries

❶ We care about the future - some futures are "better" than others

❷ The future depends on present-day decisions (plus many other factors)

❸ Operations research (OR) seeks to support decision making

➔ OR needs to help understand what may happen and how the future is shaped by decisions

The Future
NEXT EXIT

" 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

WHAT MAY HAPPEN IN THE NEXT HUNDRED YEARS

By JOHN ELFRETH WATKINS, JR.

HESE prophecies will seem strange, almost impossible. Yet they have come from the most learned and conservative minds in America. To the wisest and most careful men in our greatest institutions of science and learning I have gone, asking each in his turn to forecast for me what, in his opinion, will have been wrought in his own field of investigation before the dawn of 2001—a century

Trains One Hundred and Fifty Miles an Hour. Trains will run two miles a minute, normally; express trains one hundred and fifty miles an hour. To go from New York to San Francisco will take a day and a night by fast express. There will be cigar-shaped electric locomotives hauling long trains of cars. Cars will, like houses, be artificially cooled. Along the railroads there will be no smoke, no cinders, because coal will neither be carried nor burned. There will be no stops for water. Passengers will travel through

Grand Opera will be Telephoned to private homes, and will sound as harmonious as though enjoyed from a theatre box. Automatic instruments reproducing original airs exactly will bring the best music to the families of the untalented. Great musicians gathered in one inclosure in New York will, by manipulating electric keys, produce at the same time music from instruments arranged in theatres or halls in San Francisco or New Orleans, for instance. Thus will great bands and orchestras give long-distance

"To the wisest and most careful men of our greatest institutions of science and learning I have gone ... asking each to forecast what will have been wrought a century from now."

"The prophesies will seem strange, almost impossible ... yet they have come from the most learned and conservative minds in America."
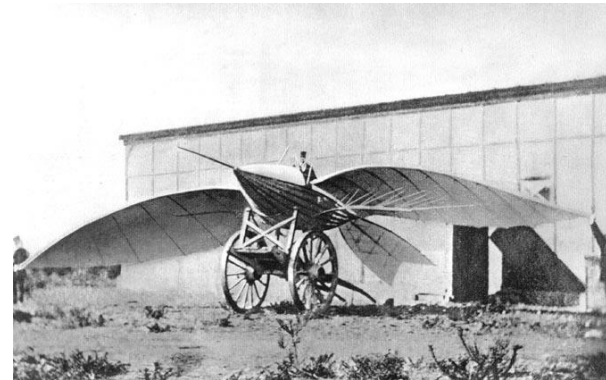
# "Wireless telephone and telegraph circuits will span the world."
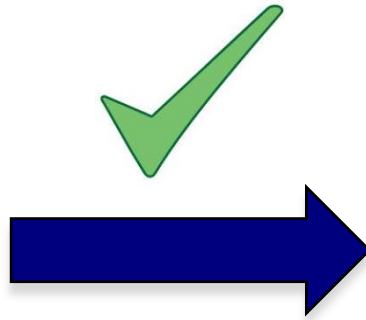
"Photographs will be telegraphed from any distance …
photographs will reproduce all of nature's colors"
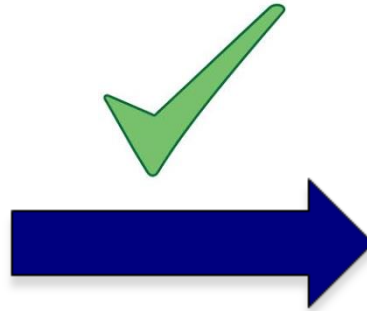
"Air-ships … will not successfully compete with surface land and water vessels for passanger or freight traffic"

"Mosquitoes, house-flies and roaches will have been exterminated"

dichlorodiphenyltrichloroethane
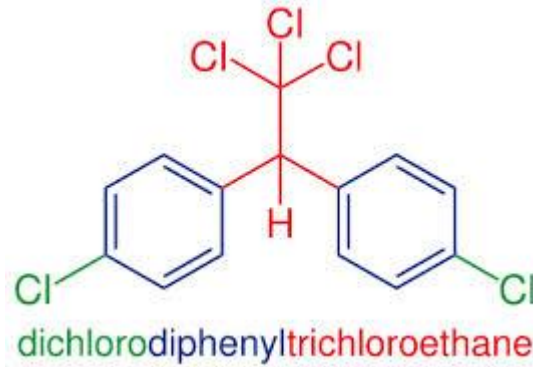
DDT

Biases in hindsight

- Many predictions strikingly accurate (mobile phones)

- **Optimism**: Most statements postulated as optimistic visions (emphasis on intended consequences instead of <u>unintended</u> ones)

- **Blind spots**: Technological discontinuities missed (fission, ICT, DNA)

- **Short-termism in predicting the long run**: Economic viability of technologies (aviation)

- **Values change, too**: Some aspirations would now offend our values (killing insects)

Societally acceptable $\subset$ Economically viable $\subset$ Technically feasible

Technology foresight

- **Martin and Irvine (1984)**
  - "… the process involved in a systematic process which attempts to look into the longer-term future of science, technology, economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefit."
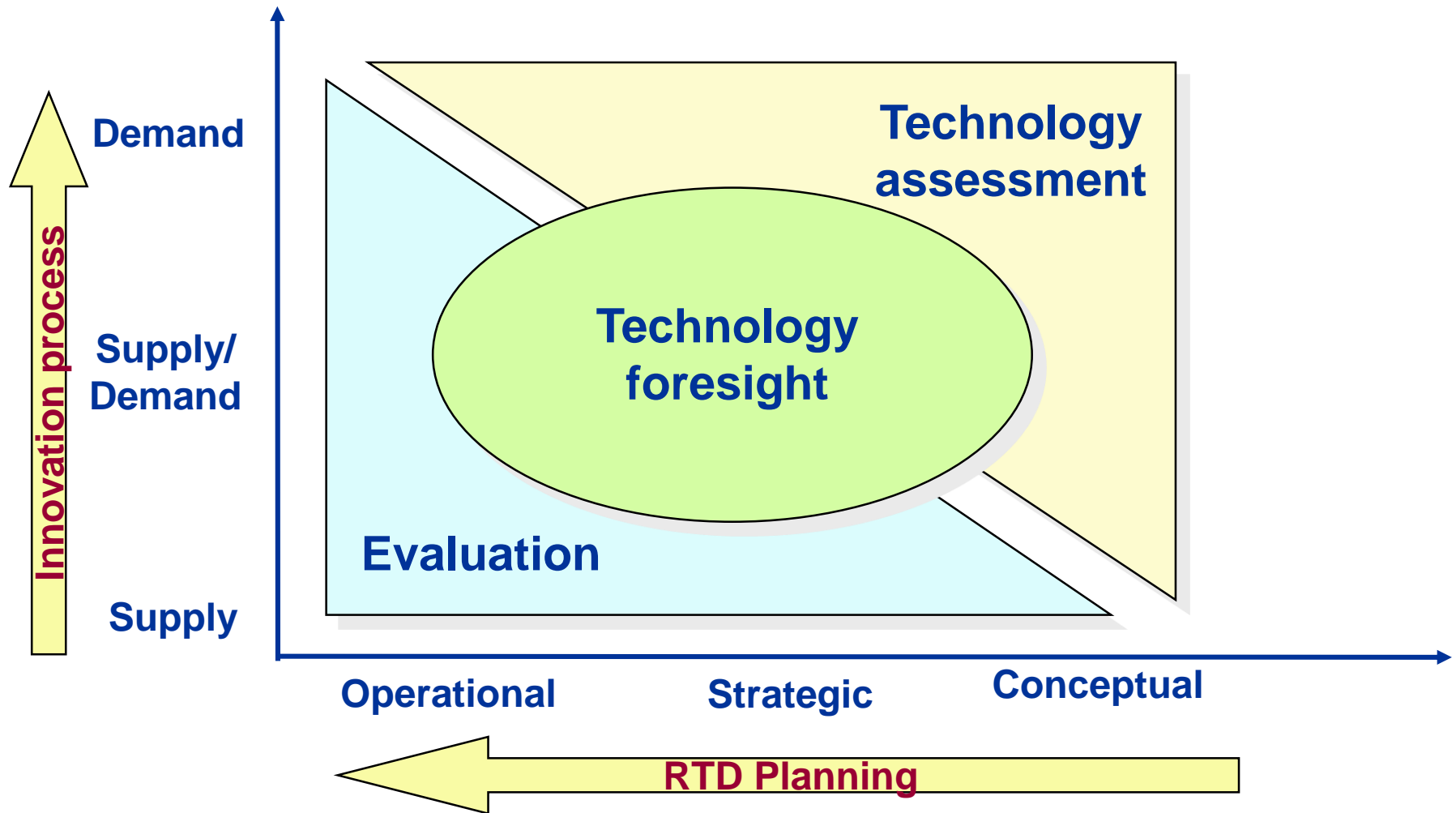
- **EU High-Level Expert Group (2002)**
  - "… a systematic, participatory, future intelligence gathering and medium-to-long-term vision-building process aimed at present-day decisions and mobilising joint action."
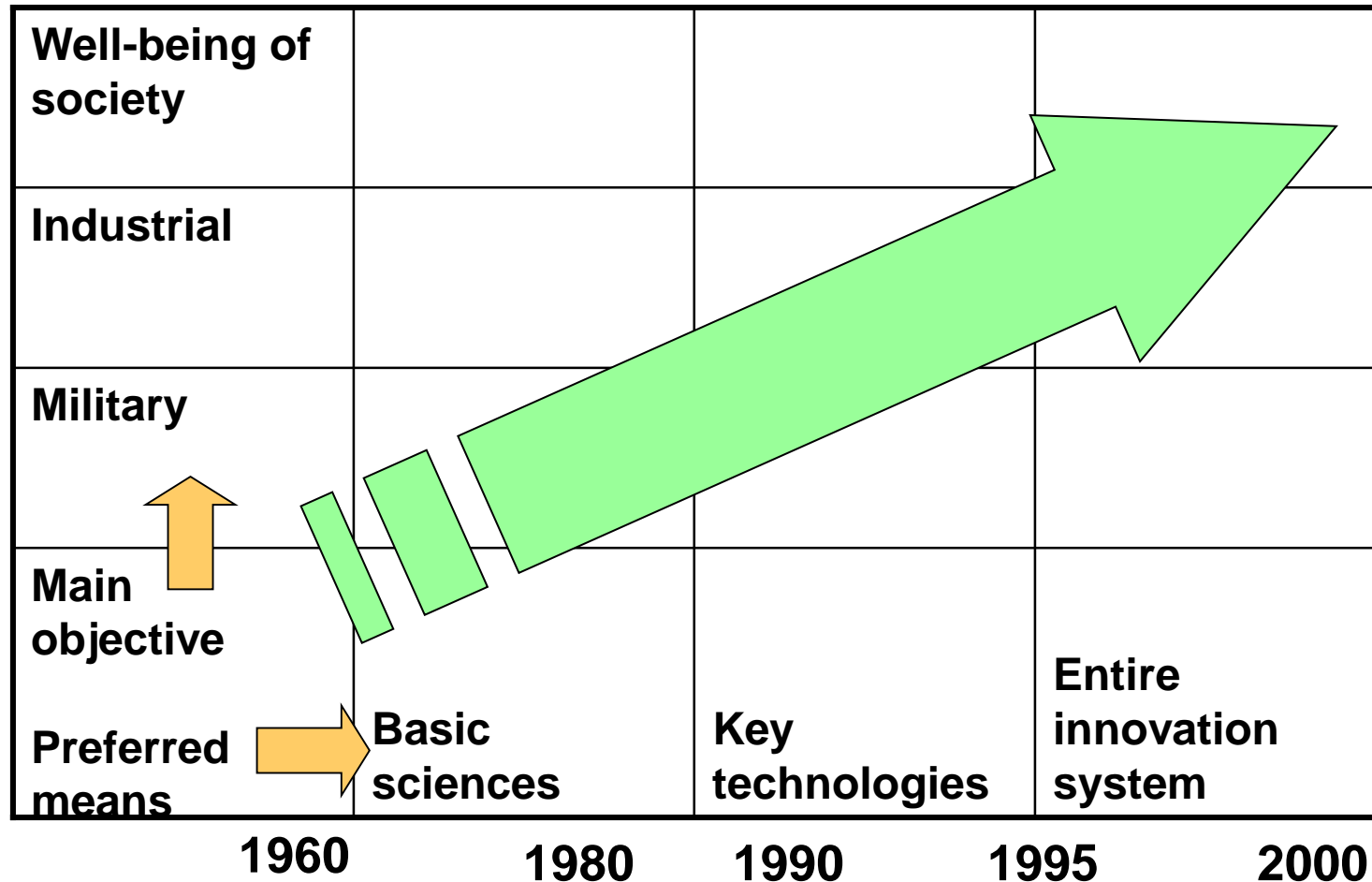
- **Salo and Cuhls (2003)**
  - "… an instrument of strategic policy intelligence which seeks to generate an enhanced understanding of possible scientific and technological developments and their impacts on economy and society, in order to support the shaping of sustainable S&T policies, the alignment of research and development (R&D) efforts with societal needs, the intensification of collaborative R&D activities and the systemic long-term development of innovation systems."

Instruments of strategic policy intelligence

Shifting emphases

	1960	1980	1990	1995	2000
Well-being of society					
Industrial					
Military					
Main objective					
Preferred means	Basic sciences		Key technologies	Entire innovation system	

Source: Caracostas & Muldur (1998)

What are the benefits of foresight?

Activity	Definition	Benefits
Framing	Scoping the process	22%
Scanning	Gathering relevant information	21%
Forecasting	Describing most likely and alternative futures	22%
Visioning	Choosing a preferred future	10%
Planning	Organizing to achieve vision	14%
Acting	Implementing the plan	23%

Hines (2007) Why Foresight? I Can Think of 316 Reasons!, Changewaves

Facing the Future: Scanning, Synthesizing and Sense-Making in Horizon Scanning

Totti Könnölä[1], Ahti Salo[2], Cristiano Cagnin[3], Vicente Carabias[3], and Eeva Vilkkumaa[2]

[1]Impetu Solutions, Madrid (Spain)
[2]Aalto University School of Scence, Espoo (Finland)
[3]JRC-IPTS, Seville (Spain)

About BEPA

Connecting Commission policy-makers with those parts of society that can fruitfully contribute to the development of policies is the first and foremost priority of the Bureau of European Policy Advisers (BEPA). The Bureau forges links between the European Commission and think tanks, academia, civil society, churches and communities of conviction.

BEPA activities, its strategic input and reports complement those of other Commission Services since they concentrate on the early stage of the policy cycle, thereby helping to shape policy options in the medium and long term. Within the Commission, BEPA holds a unique position: it operates directly under the President's authority.

Help us improve

Find what you wanted?
○ Yes ○ No
What were you looking for?

Any suggestions?

Send

Rationale

- **Understand better the state of the world in 2025 and the policy implications for the EU**

- **Provide inputs for the Commission's political agenda**

- **Complement previous work of the Directorate Science, Economy and Society in cooperation with the Bureau of European Policy Advisors of the European Commission**

Horizon Scanning …

• *… is regarded here as a creative process of collective sense-making by way of collecting and synthesizing observations that hold potential for the formulation of pertinent future developments and the derivation of actionable implications on decision-making*

• Builds on the actor's ability to perceive, interpret and construct meaning

Key Questions in Horizon Scanning

• How to recognize signals?

• How to elaborate corresponding policy issues?

• How to synthesize such signals and issues into meaningful clusters?

• How to facilitate collective sense-making in the analysis of clusters?

• How to recognize the big picture of societal change?

• How to develop respective policy recommendations?

Horizon scanning

- **<u>Literature review</u>:** Analyze recent foresight and forward looking studies and FTA Conference survey to identify
  - ✓ Trends
  - ✓ Emerging trends
  - ✓ Unexpected and improbable (rare) events with high relevance for EU

- **<u>Online survey</u>:** Assess results on their relevance, novelty and probability to identify interesting issues for discussion in the final workshop

- **<u>Final workshop</u>:** Define and refine cross-cutting challenges and policy implications for the EU

Literature Review

- **Scan and analyse trends and rare events in:**
  - ✓ Demography, (im)migration, and urbanisation
  - ✓ Economy, trade, and financial flows
  - ✓ Environment, energy and climate change, and agriculture
  - ✓ Research, innovation and (e)education
  - ✓ (e)Governance and (e)social cohesion
  - ✓ Defence and security, health and food, and space

Literature Review

- **Data collected:**
  - ✓ ~21 reports per area
  - ✓ Basic facts or projections for each issue
  - ✓ Timeframe, related drivers and weak signals
  - ✓ Impact of the issue on each of the 6 areas
  - ✓ Implications and recommendations for EU policy making

- **381 issues in all 6 areas:**
  - ✓ 73 – Demography, (im)migration, and urbanisation
  - ✓ 44 – Economy, trade, and financial flows
  - ✓ 90 – Environment, energy and climate change, and agriculture
  - ✓ 80 – Research, innovation and (e)education
  - ✓ 52 –(e)Governance and (e)social cohesion
  - ✓ 42 – Defence and security, health and food, and space

Online Survey

- **Rationale**
  - ✓ Identify the most interesting issues in view of <u>a wider community</u> of experts, and hence help focus the workshop
  - ✓ Generate more issues

- **381 issues divided into 6 sub-areas; participants rated them on three criteria using a 7 point Likert-scale:**
  - ✓ <u>Relevance</u> for EU policy making
  - ✓ <u>Novelty</u> in comparison to earlier policy debates
  - ✓ <u>Probability of occurrence</u> by 2025

Online Survey

- **Around 270 participants:**
  - ✓ Targeted field experts, those reviewing the literature and their networks
  - ✓ JRC-IPTS FTA database

- **Number of participants per area:**
  - ✓ 78 – Demography, (im)migration, and urbanisation
  - ✓ 20 – Economy, trade, and financial flows
  - ✓ 33 – Environment, energy and climate change, and agriculture
  - ✓ 73 – Research, innovation and (e)education
  - ✓ 60 – (e)Governance and (e)social cohesion
  - ✓ 12 – Defence and security, health and food, and space

Online Survey Analysis

- **Robust Portfolio Modelling (RPM) for synthesizing evaluations through three analyses (Könnölä, Brummer, Salo, 2007):**

  - ✓ Mean-oriented analysis
    (relevance mean > novelty mean > probability mean)

  - ✓ Rare-event oriented analysis
    (inverse probability mean > novelty mean > relevance mean)

  - ✓ Variance-oriented analysis
    (novelty variance > relevance variance > probability variance)
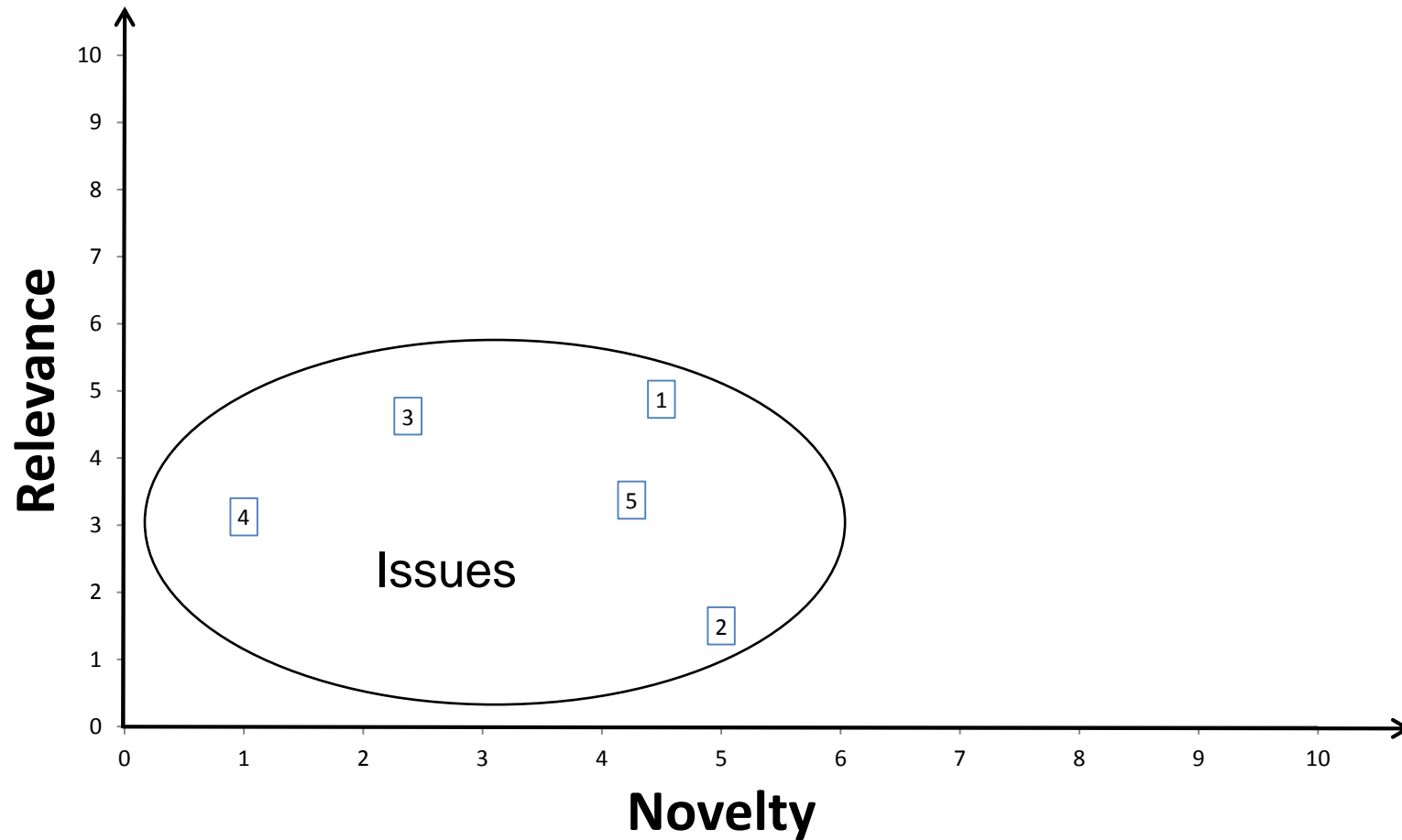
Expert evaluations

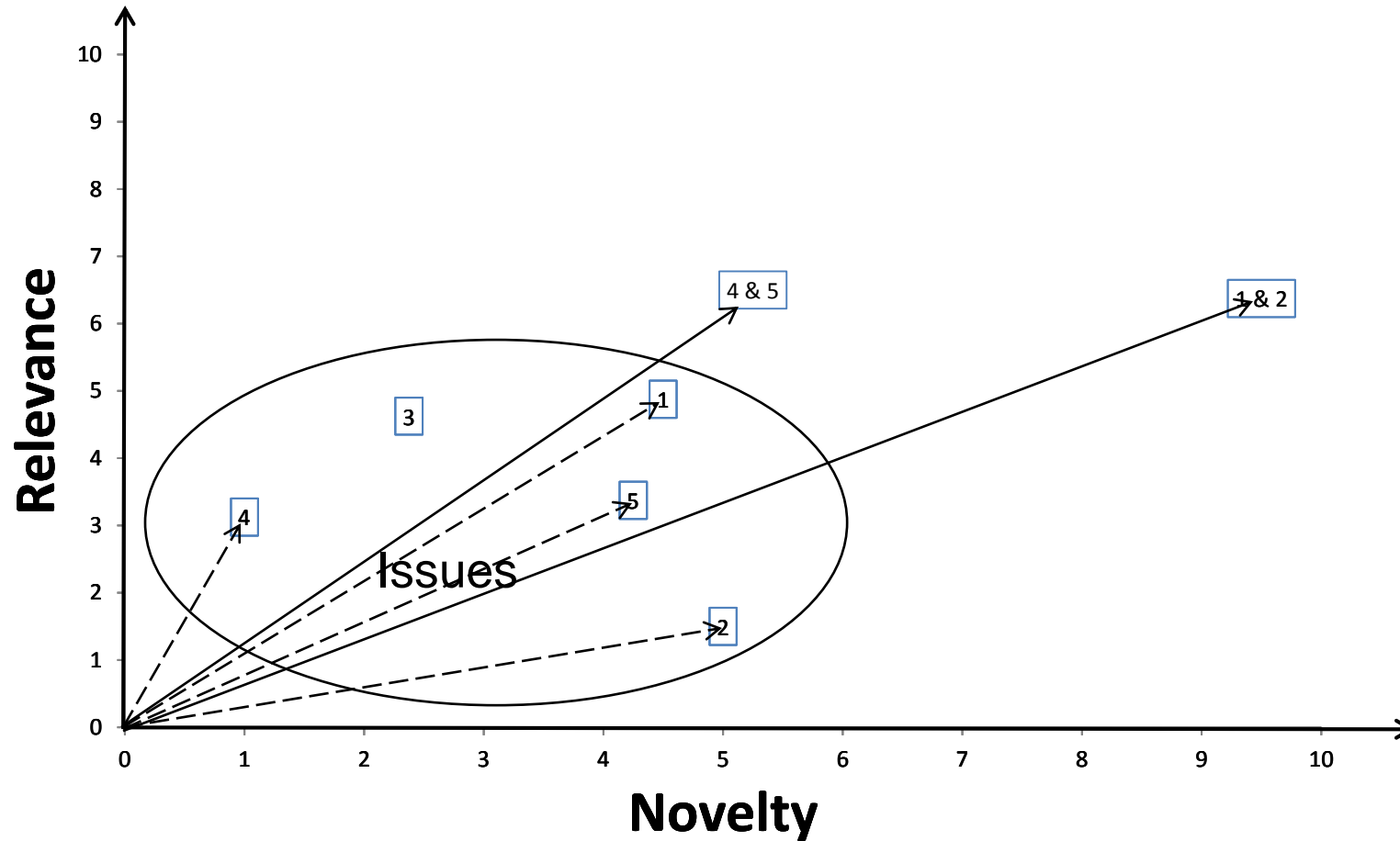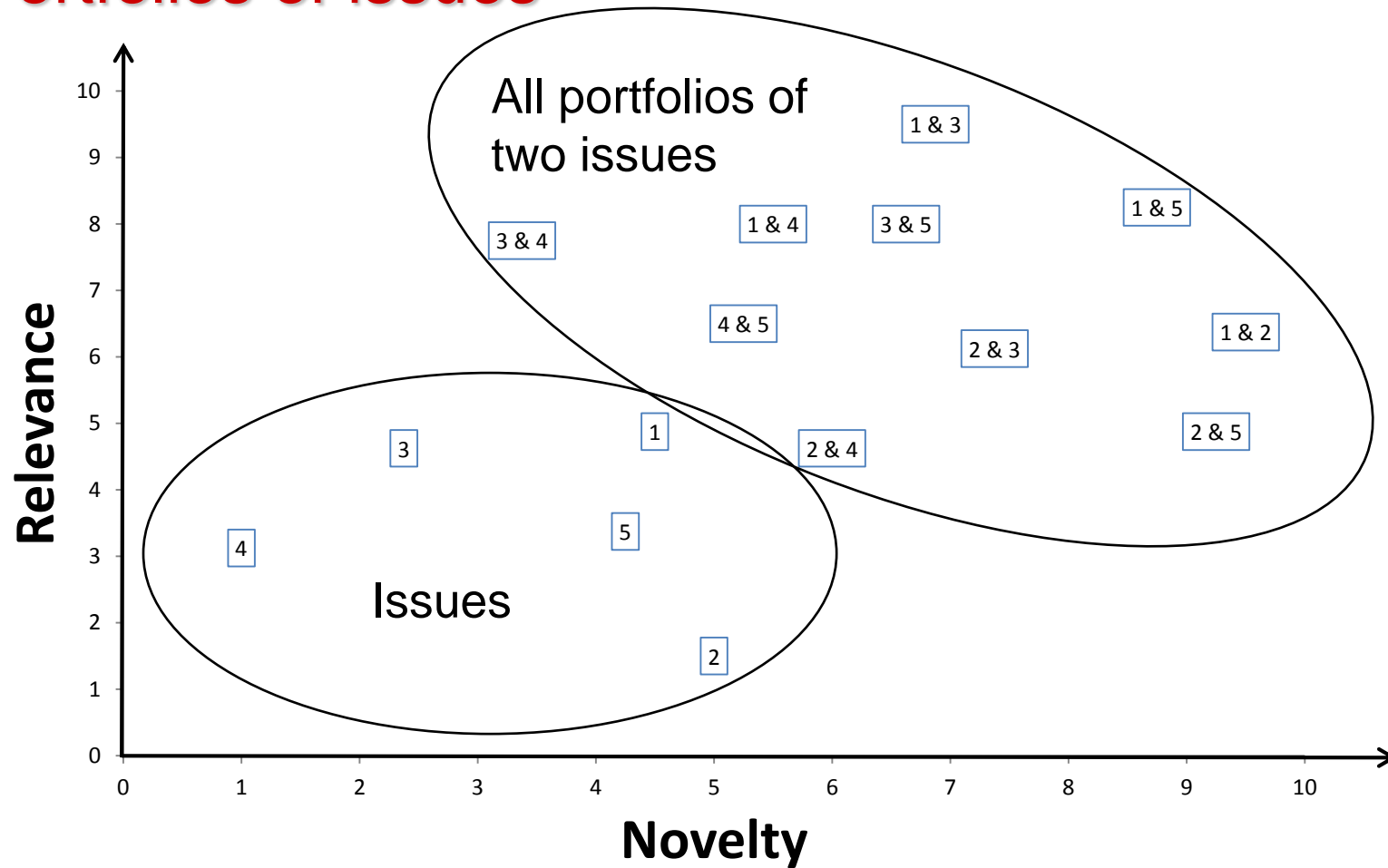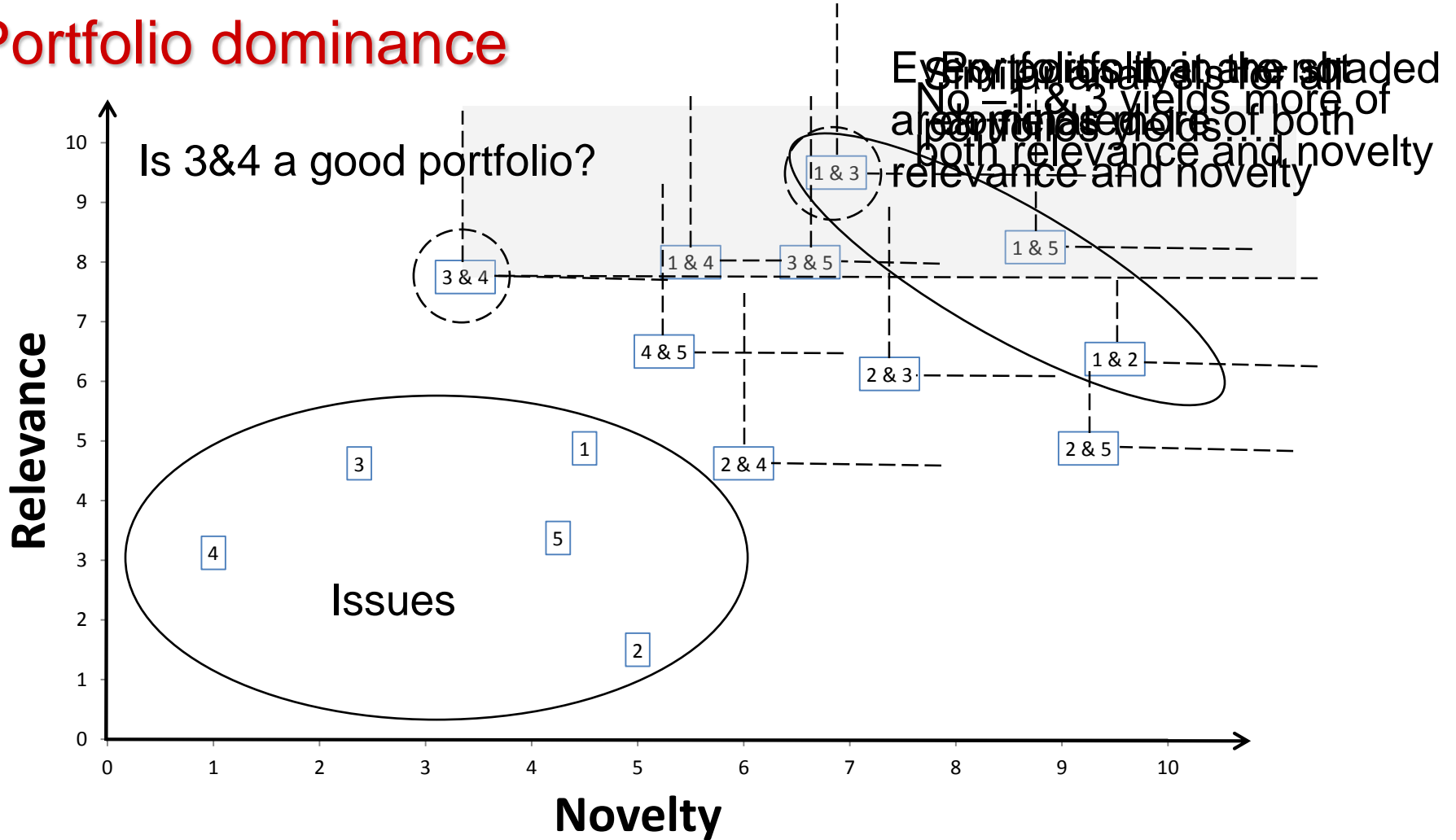| Evaluations for Issue 1		
Expert	Nov.	Rel.
1	4	5
2	7	5
3	3	7
4	6	6
5	1	4
6	6	4
7	7	3
8	2	5
Mean	4.5	4.9
Std dev	2.3	1.2
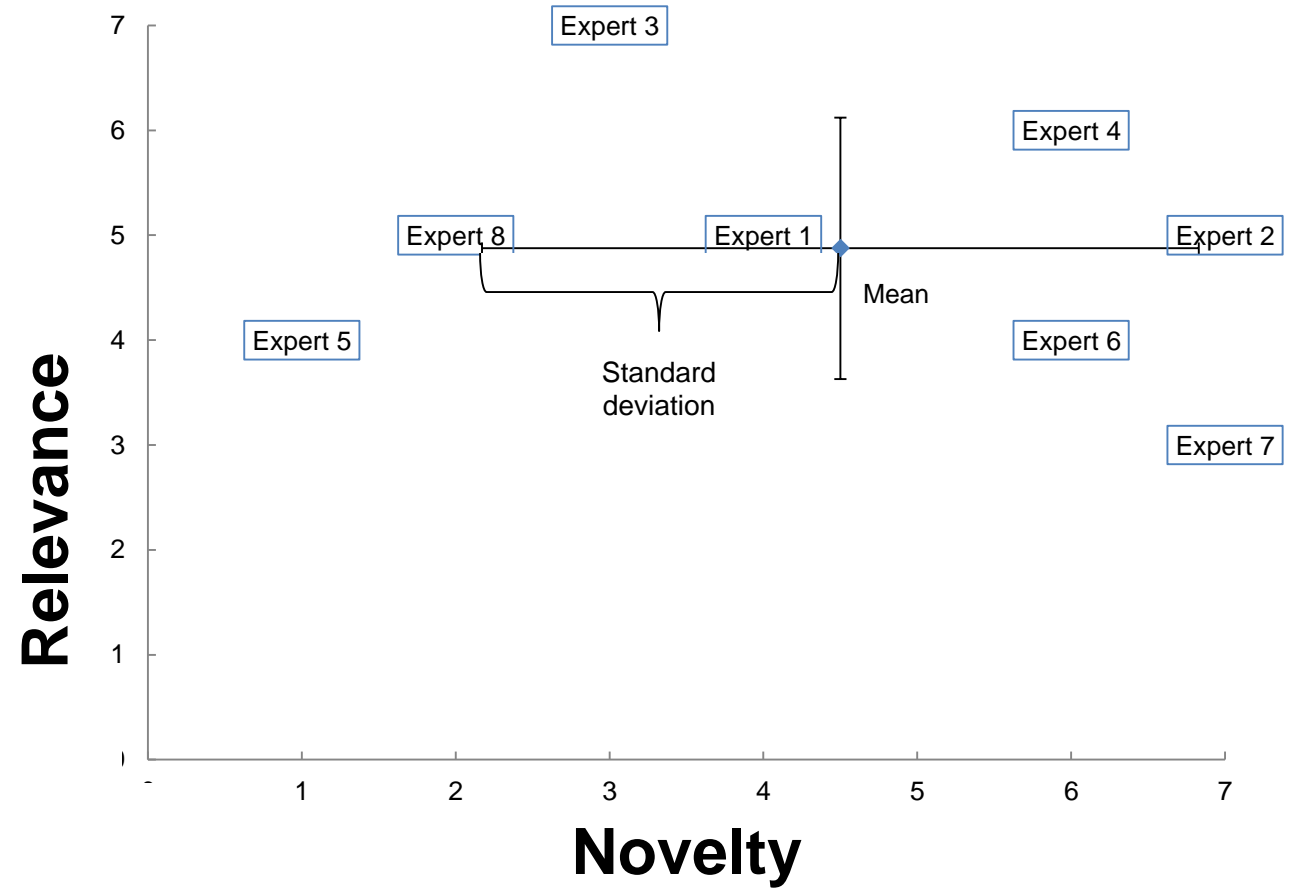
Evaluations of multiple issues
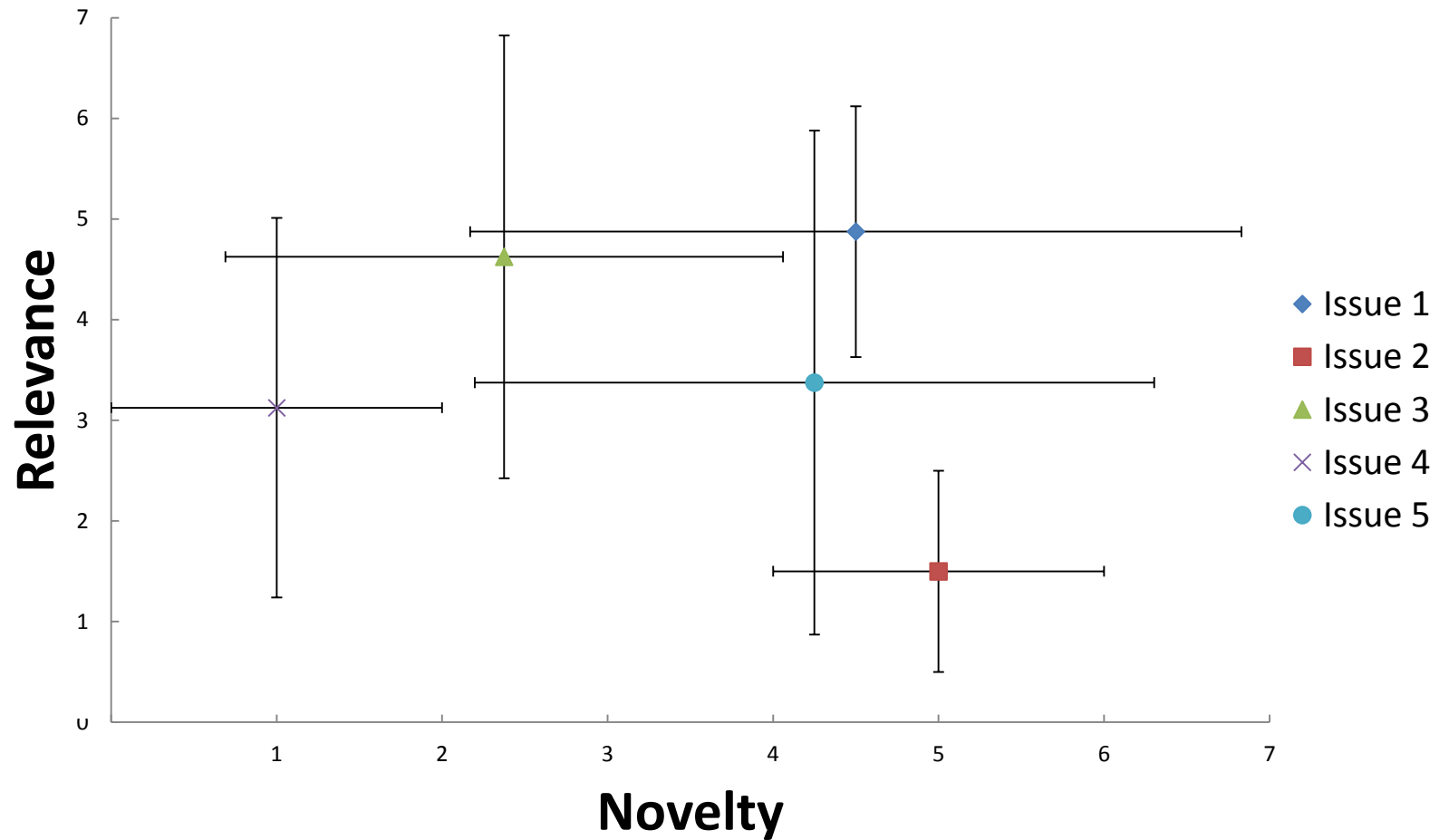
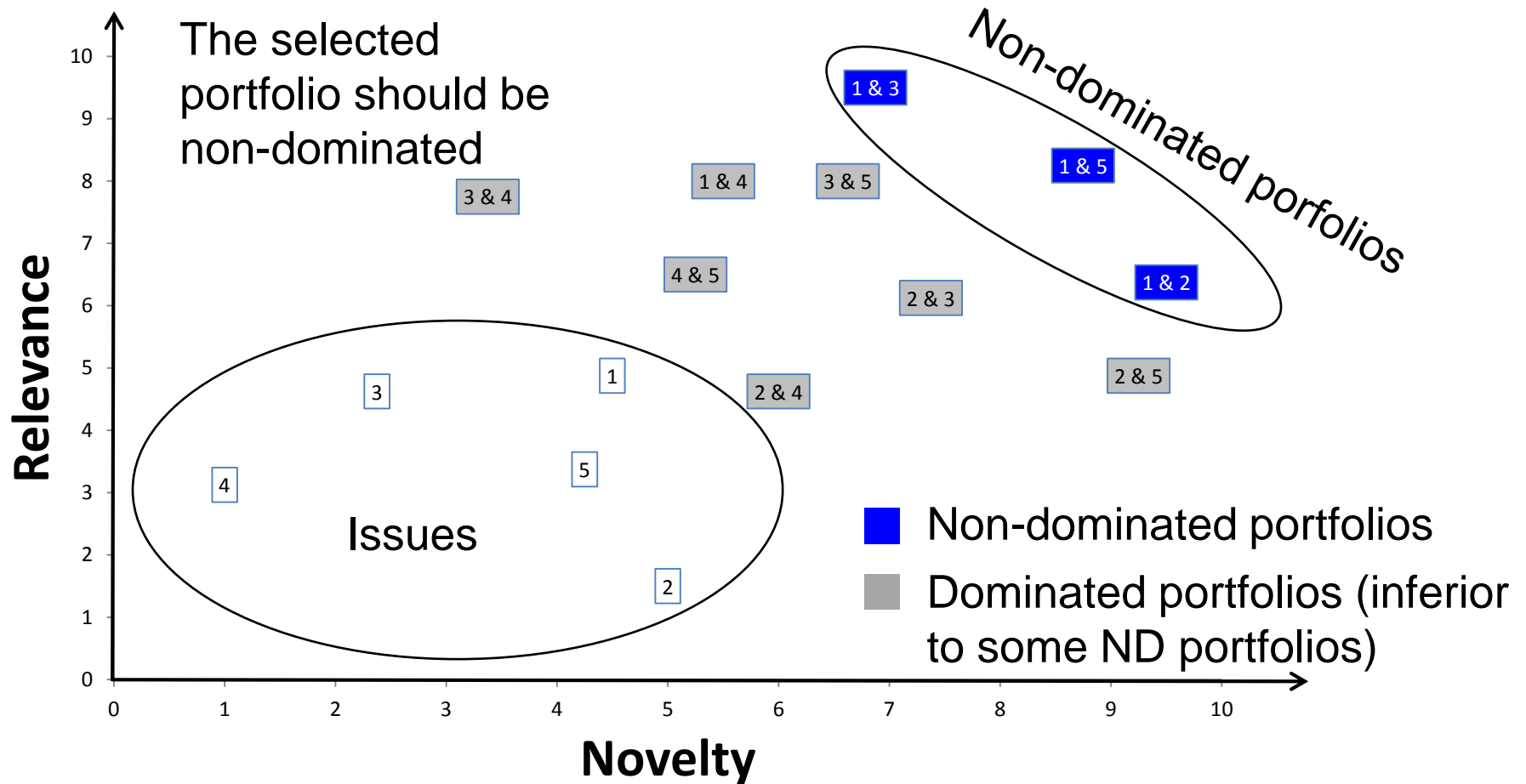# Mean-oriented analysis

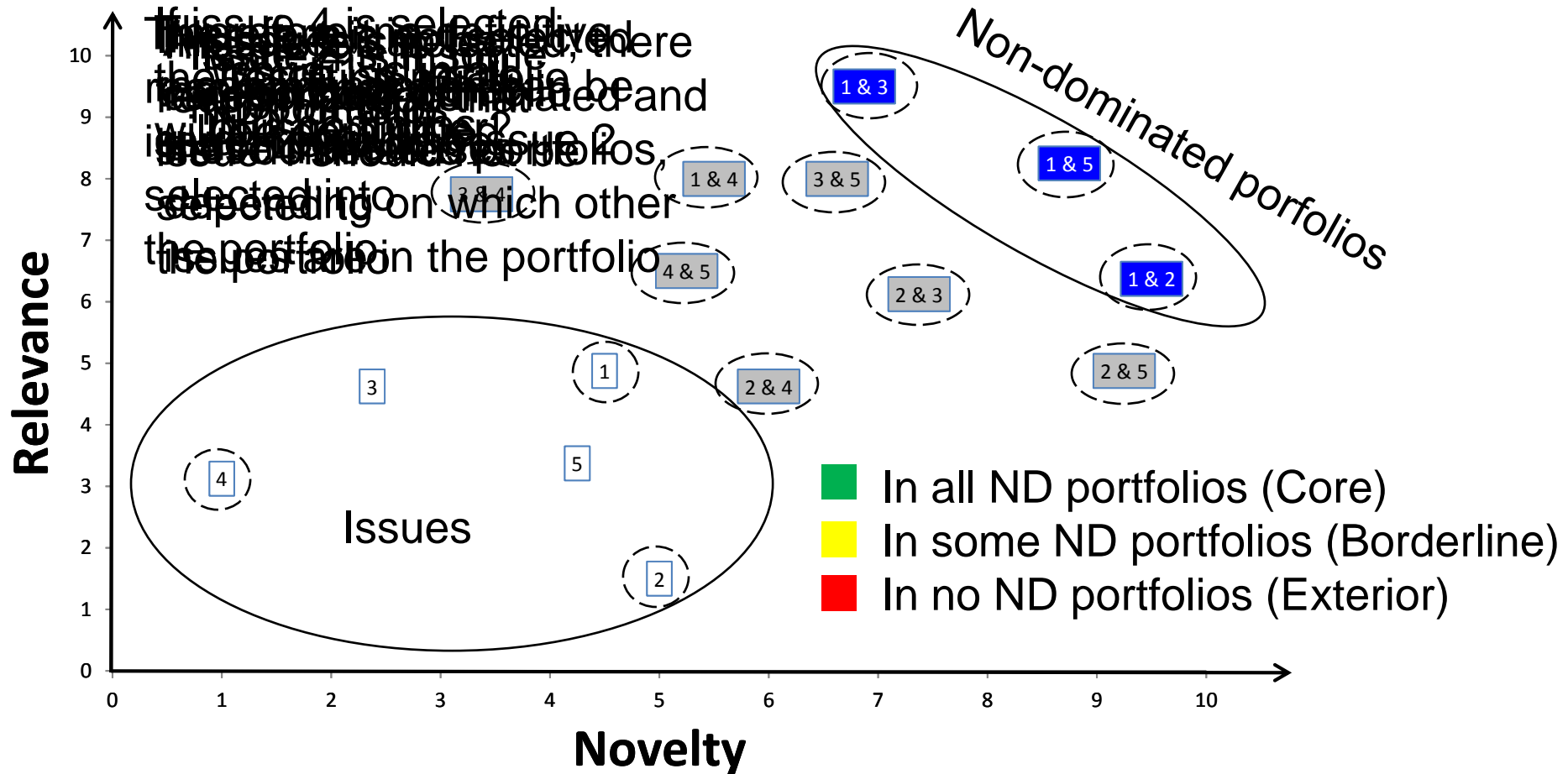# Combining issues into portfolios

Portfolio dominance

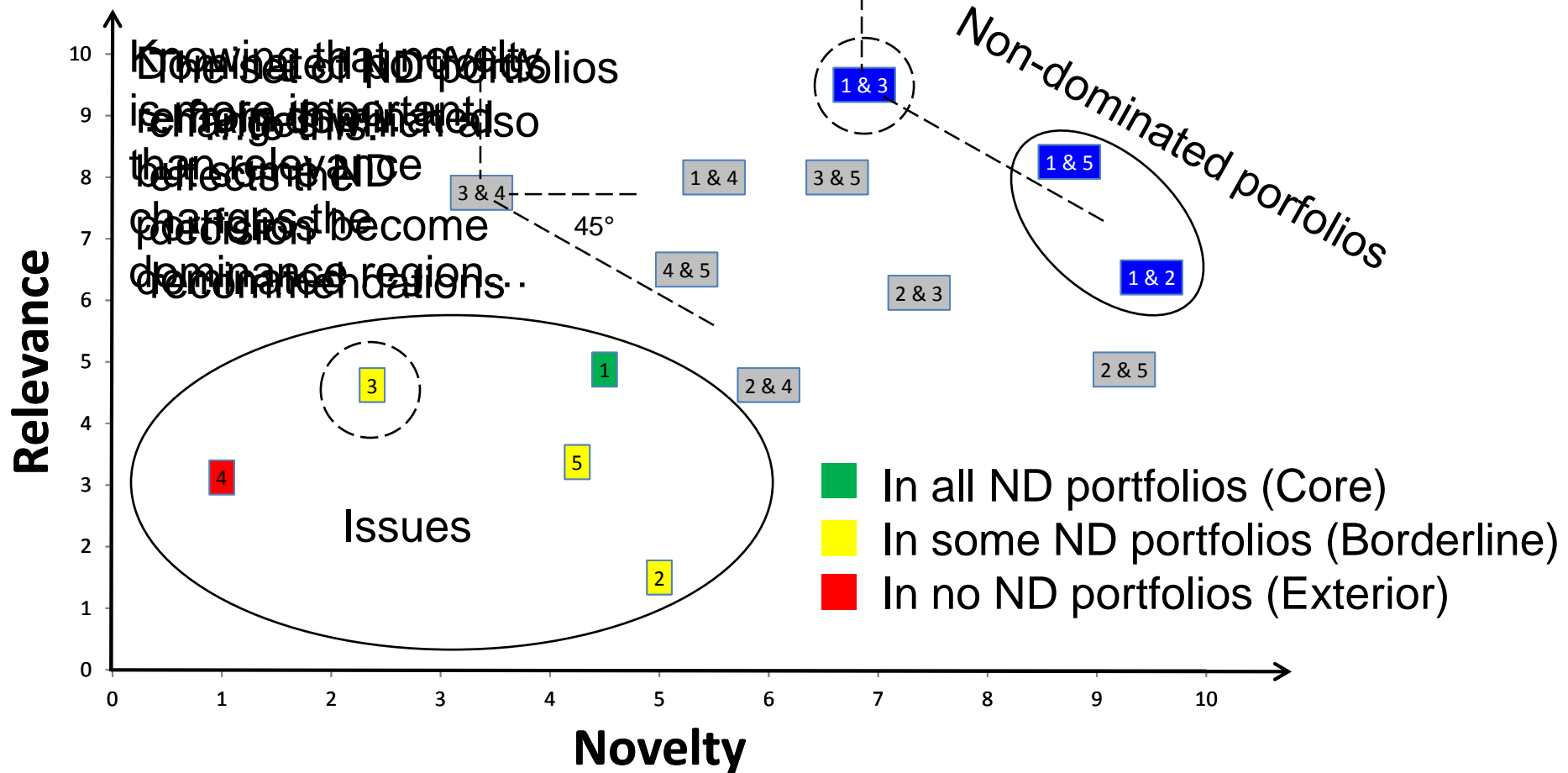# Non-dominated portfolios (ND portfolios)

The selected portfolio should be non-dominated

Non-dominated porfolios

Issues

■ Non-dominated portfolios

■ Dominated portfolios (inferior to some ND portfolios)

Comparing issues

Comparing issues with some preference information

Non-dominated porfolios

Knowing that novelty is more important than relevance changes the dominance region...

One set of ND portfolios remains but are also ... become recommendations

Denser set of ND portfolios reflect this and also affects the ... become recommendations

45°

Relevance

Novelty

Issues

■ In all ND portfolios (Core)
■ In some ND portfolios (Borderline)
■ In no ND portfolios (Exterior)

JRC
EUROPEAN COMMISSION

Ex: economy, trade, and financial flows

ipts
Institute for
Prospective
Technological Studies

Facing the future: global challenges in 2025 and EU policy implications – 11 - 12 June 2009
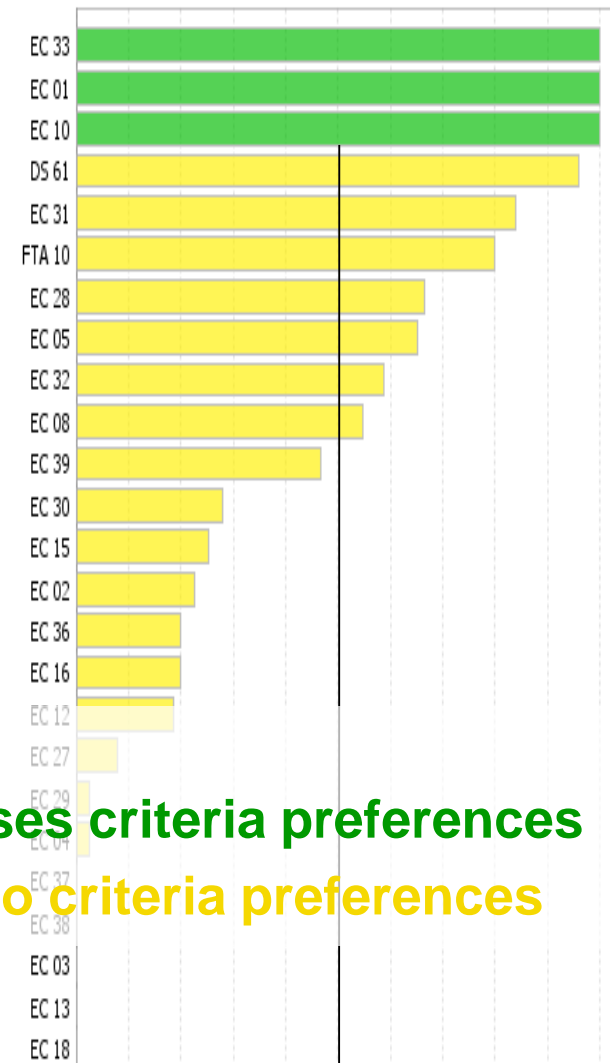
‹#›

Mean-oriented analysis
Relevance > Novelty >
Probability (means)
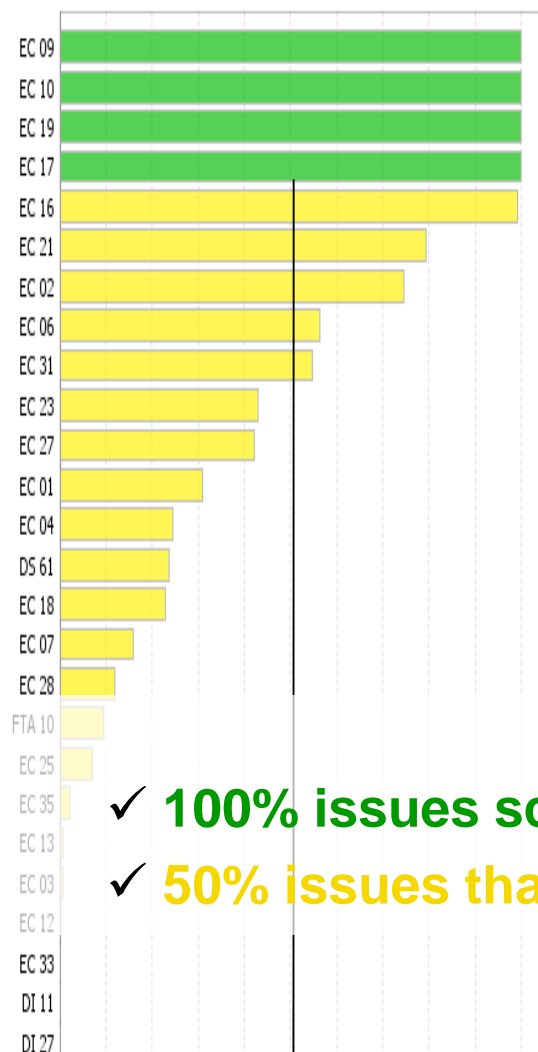
Rare event oriented analysis
Inverse probability > Novelty >
Relevance (means)
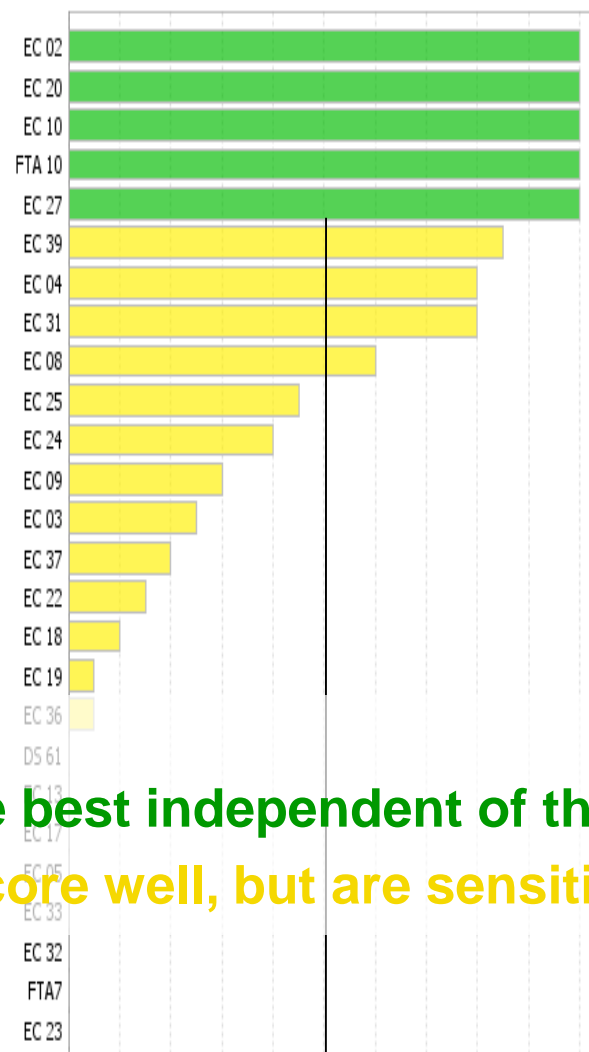
Variance-oriented analysis
Novelty > Relevance >
Probability (variance)

✓ **100% issues score best independent of the uses criteria preferences**

✓ **50% issues that score well, but are sensitive to criteria preferences**

List resulting from analysis

Some issues in this area are highlighted in **bold**, *italic* or <u>underlined,</u> with the following meaning:

This analysis identifies issues that many respondents consider relevant, novel and probable.

M	**Mean-oriented analysis**	> 50%	100%
	(relevance mean > novelty mean > probability mean)		

This analysis identifies issues that respondents consider to be improbable but are novel and relevant.

R	*Rare-event oriented analysis*	> 50%	100%
	(inverse probability mean > novelty mean > relevance mean)		

<u>This analysis identifies issues on which respondents' views differ with regards to novelty, relevance and probability.</u>

V	<u>Variance-oriented analysis</u>	<u>> 50%</u>	<u>100%</u>
	<u>(novelty variance > relevance variance > probability variance)</u>		

Economy, trade, and financial flows

- Variance **oriented analysis (issues for which views differ with regard to novelty > relevance > probability)**

  ✓ **Increasing global structural unemployment** due to shortages and mismatches of skills since globalisation and an ageing population determines new demand and supply of future skills
  ✓ **UK entry into the European Monetary Union by 2025**
  ✓ By 2025 the Euro will become the dominant international currency
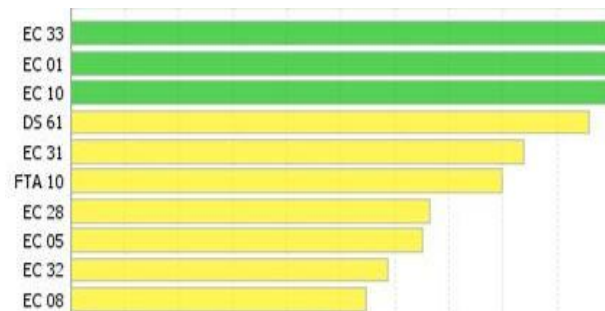
Some reflections

- It is difficult to impose rigorous research controls in real-world policy processes

- Yet there are opportunities for methodological work which is interesting from perspective behavioral research, e.g.

  – Blind spots
    - ➔ Broad consultation of stakeholder groups
    - ➔ Emphasis on variability and low probability events

  – Short-termism
    - ➔ Ex post analyses of analogous historical benchmarks
    - ➔ Comparisons between expert judgements and model-based results

  – Anchoring
    - ➔ Expanding the full range of possibilities
    - ➔ Anonymity of participation
    - ➔ Iterative learning in multiple rounds

- Political decisions are interwoven in complex ways:
  It is instructive to get involved

International Series in
Operations Research & Management Science

Ahti Salo
Jeffrey Keisler
Alec Morton *Editors*

Portfolio Decision Analysis

Improved Methods for Resource Allocation

Springer

" By Portfolio Decision Analysis (PDA) we mean a body of theory, methods, and practice

which seeks to help decision makers make informed multiple selections from a discrete set of alternatives

through mathematical modeling that accounts for relevant constraints, preferences, and uncertainties."

Winner of the 2013 Publication Award of the Decision Analysis Society of the Institute for Operations Research and the Management Sciences (INFORMS)

Characteristics of project portfolio selection

- Only some proposals can be selected

- Decisions are constrained by limited resources

- There are difference measures of "value"
  (e.g. expected net present value)

- Decisions must be taken on <u>uncertain value estimates</u>

- Realized performance falls often short of expectations; this has
  been attributed to <u>purposeful misrepresentation</u> of information
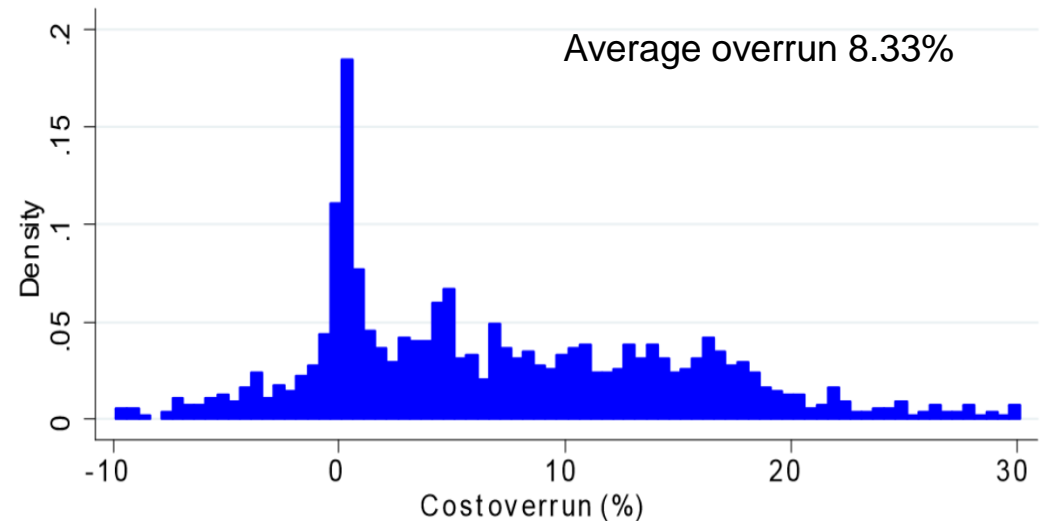 (Flyjberg et al., 2002)

Cost overruns in public procurement

Large transportation infrastructure projects, N=258

Average overrun 27.6%
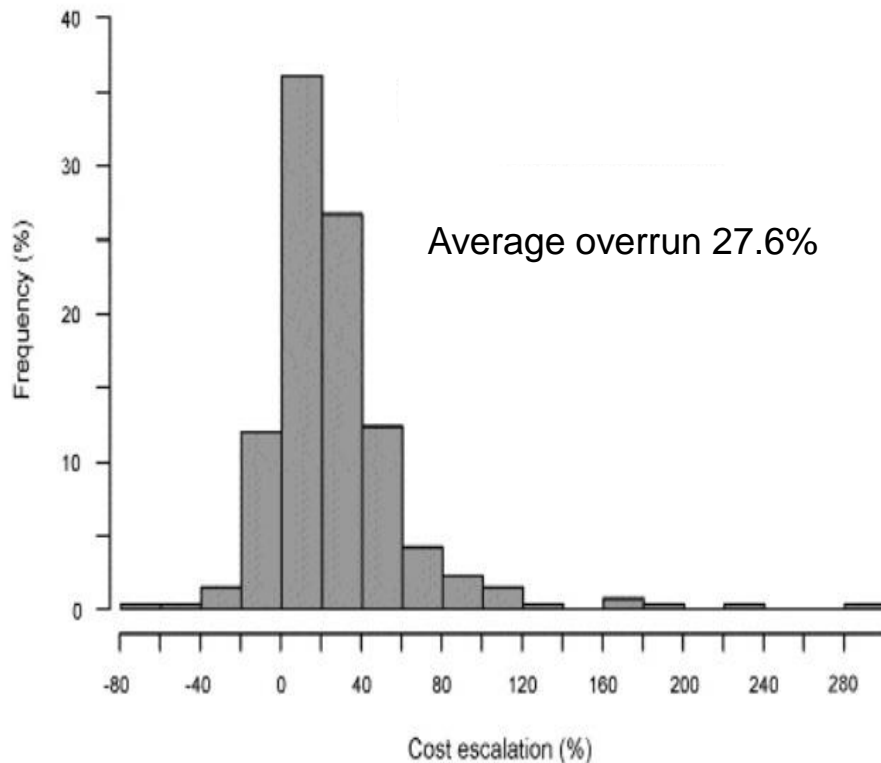
Source: Flyvbjerg *et al.* (2002), Underestimating costs in public work projects – error or lie? *Journal of the American Planning Association,* Vol. 68, pp. 279-295.

**Small public works projects, N=1093**

Average overrun 8.33%

Source: Bucciol et al. (2011), Cost overrun and auction format in public works, *Working Paper Series*, *WP 17*, Department of Economics, University of Verona.

45

Optimizer's curse

- Even when value estimates are unbiased, projects whose values have been overestimated tend have a higher chance of getting selected

- <u>On average</u>, the realized value of the portfolio is therefore less than what the estimates would suggest

- Thus, the decision maker should <u>expect to be disappointed</u> with the performance of the selected portfolio

Example of choosing 5 projects out of 12
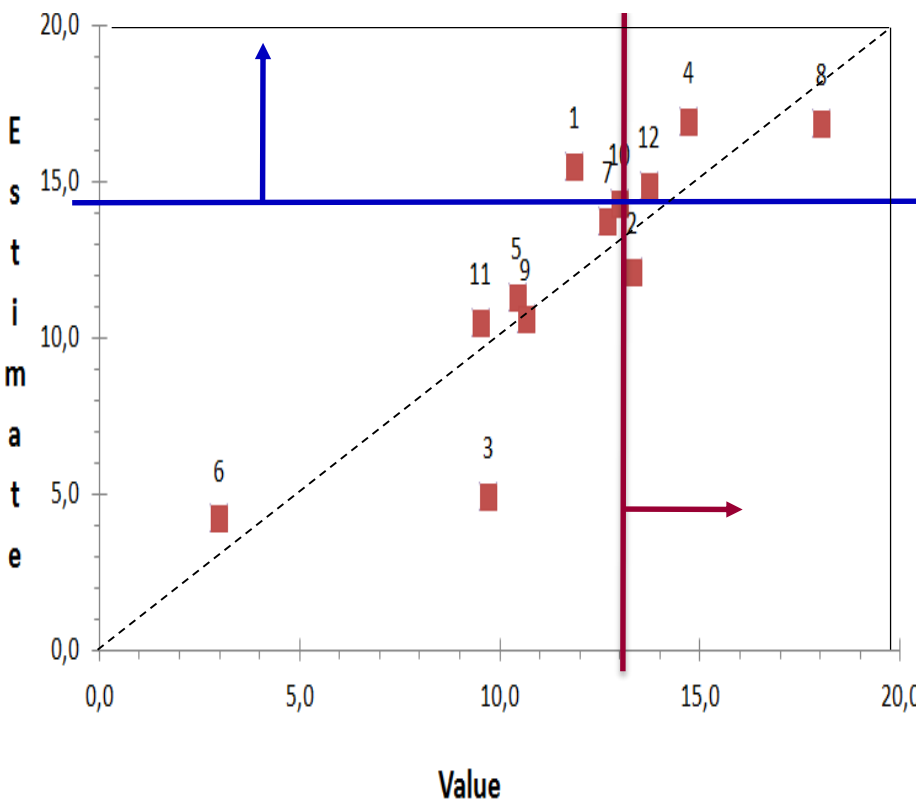
Project number	True project value	Estimated project value	Portfolio which maximizes sum of estimates	Portfolio which maximizes sum of true values
1	11,9	15,5	1	0
2	13,3	12,1	0	1
3	9,7	4,9	0	0
4	14,7	17,0	1	1
5	10,4	11,3	0	0
6	3,0	4,2	0	0
7	12,7	13,8	0	0
8	18,0	16,9	1	1
9	10,7	10,6	0	0
10	13,0	14,3	1	1
11	9,5	10,5	0	0
12	13,7	14,9	1	1
	78,5	71,3		72,8
	Sum of estimates	Sum of true values		Value of the optimum portfolio

Implications for project selection

- <u>On average</u>, the selected portfolio falls short of expectations

- This optimizer's curse has been (partly erroneously) attributed to purposeful misrepresentation of information

- The expected disappointment can be eliminated by
  ❶ Characterizing the prior distribution of values for of project proposals
  ❷ Assessing how uncertain the initial estimates are
  ❸ Applying Bayes' formula to revise these estimates
  ❹ Using these <u>revised</u> estimates to inform decisions
  This revision shifts estimates "towards the mean" and eliminates the expected disappointment (Vilkkumaa, Liesiö, Salo, 2014)

<u>Takeaway</u>: Not all alledged "behavioural" impacts are such!