

S.NET Conference, Twente, October 2012

An Assessment of Quantitative Methods for Future Technology Analysis (FTA)

Work in progress – comments most welcome

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Motivation: a review of QUANTITATIVE-based Future Technology Analysis (FTA)

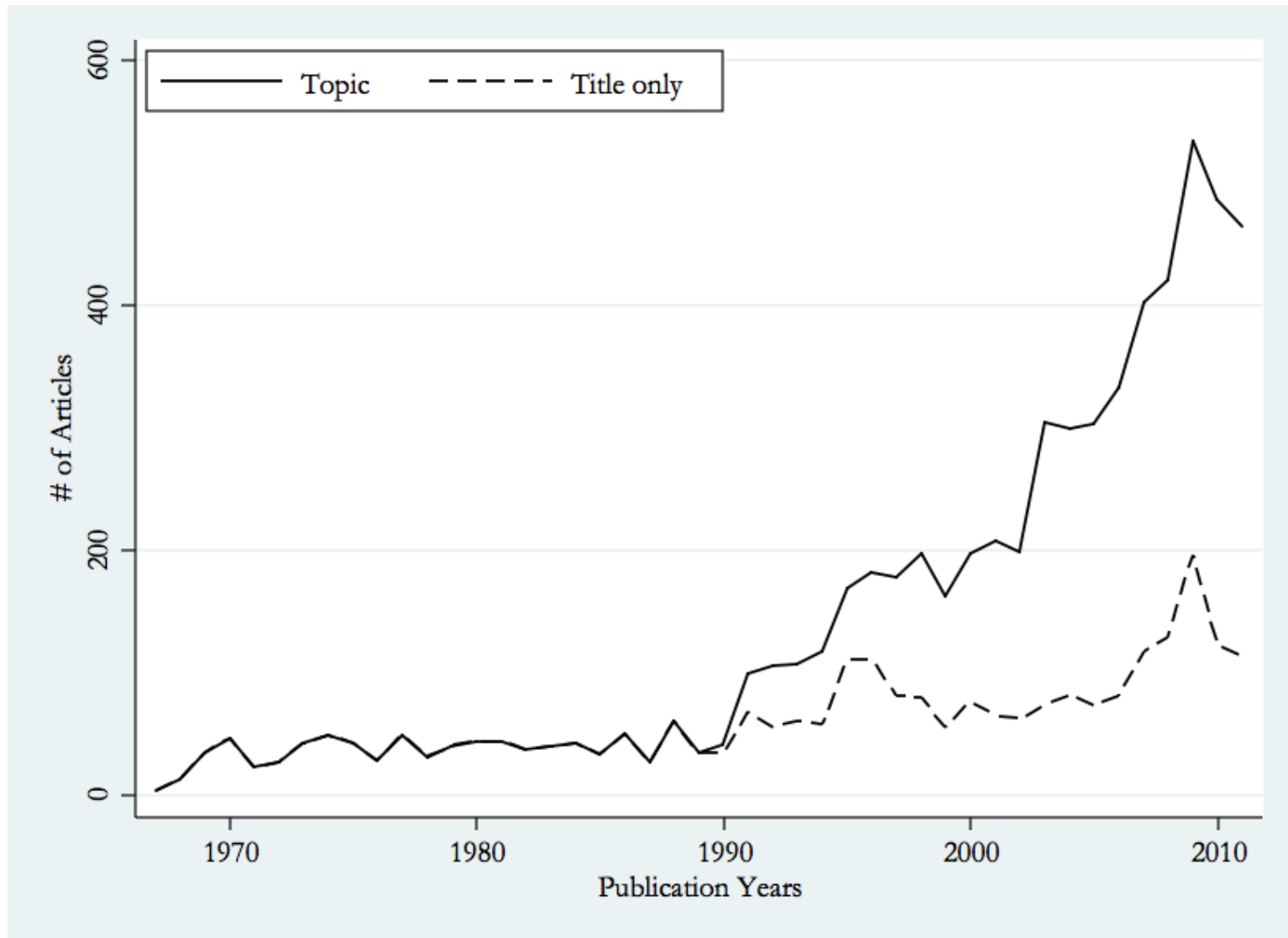
NESTA (UK gov. S&T think tank):

Review on the current state of the art in using **quantitative techniques to understand emerging trends in technology** and technology-related business activity.

Context:

- **Proliferation of methods for FTA** that investigate technology trends using:
 - Structured databases on publications, patents, alliances
 - **Web-based unstructured data**
 - Associated consultancies (e.g. Quid, <http://quid.com/>)

Increase and decrease of FTA publications



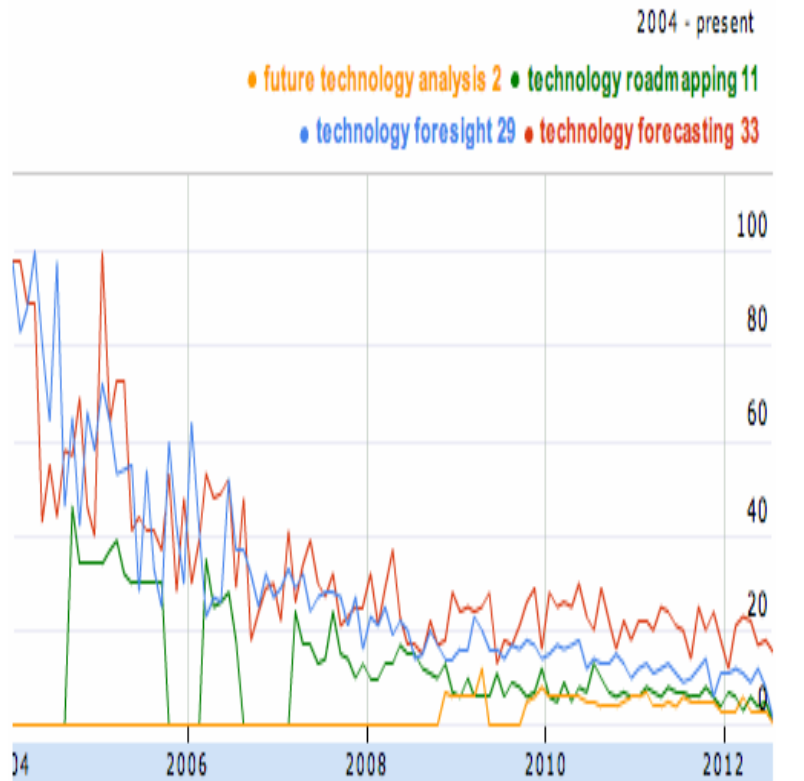
Based on keyword search in Web of Knowledge (1967-2011)

Apparent shift of interest towards new FTA methods (based on Google trends)

Traditional FTA methods:

Foresight, forecasting, roadmapping

Interest Over Time



2004

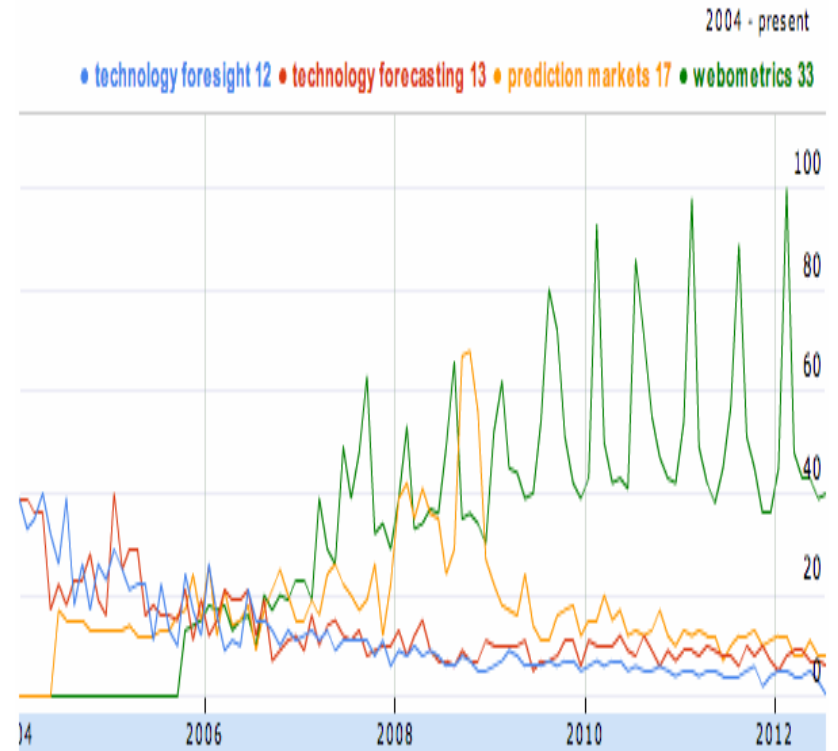
2008

2012

New FTA methods:

Webometrics, Prediction markets

Interest Over Time



2004

2008

2012

Defining of “Future Technology Analysis (FTA)”

- **Our (broad) definition** (following Porter, 2010);
FTA are techniques that provide an understanding of current S&T conditions and problems, project them in to the future, and forecast/explore changes in technology.
Some FTA tools also may allow the study of future S&T scenarios that shape social and economic conditions.
- “[A]n umbrella term for a broad set of activities that facilitate decision-making and coordinated action, especially in STI policy-making” [p. 265]; (Eerola and Miles, 2011)
- Included/used in VARIOUS types of methodologies such as:
 - tech foresight, forecasting, intelligence, roadmapping, nowcasting and tech assessment (Porter, 2010)

Focus on **quantitative** FTA techniques (remit of NESTA tender)

Review and classification of FTAs (not presented today)

- Purposes (e.g. data gathering or for inference)
- Contexts and organisations of usage
- Main drivers and Time horizon
- Strengths and weaknesses

Challenges in review

- FTA quantitative techniques are used as part (not whole) of a wider future-oriented appraisal process.
- Same quant FTA use may differ between broader methodologies
 - E.g. pubs/cite counts → Prediction of successful tech (forecasting)
→ Monitoring of available techs (foresight)
- De facto tendency of quantitative methods to “forecasting”?
 - Reducing inputs to consider, uncertainty and potential outcomes.
 - “Closing down” possible futures

Discussion: Opening up vs. Closing down (Stirling, 2008, STHV)

FTAs techniques are part of appraisal processes

- **Appraisal:**
‘the ensemble of processes through which knowledges are gathered and produced in order to inform decision-making and wider institutional commitments’ Leach et al. (2008)
- **Opening up:** degree to which methods’ outputs **provide an array** of options.
- **Closing down:** degree to which methods’ outputs **reduce the array** of options.

In Quantitative vs. Qualitative debate the implicit assumptions are

- More quantitative → Less dimensions → Closing down
- More qualitative → More dimensions → Opening up

Discussion: Opening up vs. Closing down (Stirling, 2008, STHV)

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This exercise: Investigate HOW different quantitative FTAs

- Close down or Open up technological options.

A classification of quantitative FTA techniques

Selected techniques to be used as examples

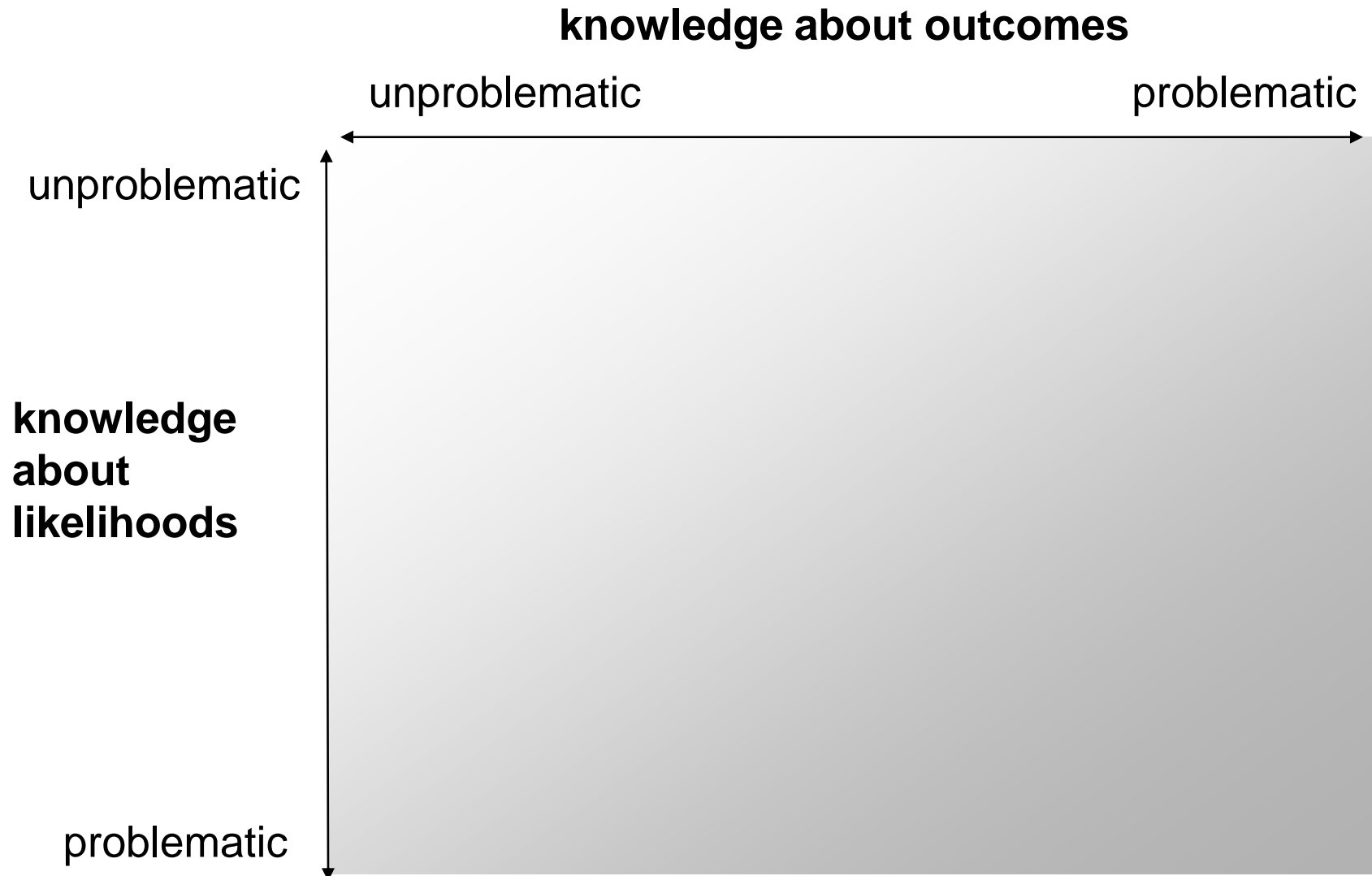
	Descriptive		Positive		Data gathering		Forecast		Inference		Foresight		Prescriptive
	Positive		Data gathering		Forecast		Inference		Foresight		Prescriptive	Normative	
	Forecast		Inference		Foresight		Foresight		Foresight		Foresight		
Creative	Monitor & intellig.	Descript. & matrices	Statistical methods	Trends analyses	Economic methods	Simulation Models	Scenarios	Roadmaps	Valuing / decision				
<i>TRIZ</i>	<i>Bibliometrics</i>	<i>Bibliometrics</i>	<i>Cross impact analysis</i>	<i>Long wave models</i>	<i>Input Output</i>	<i>Agent modelling</i>	<i>RDM</i>	<i>Roadmapping</i>	<i>Multicriteria decision analysis</i>				<i>AHP</i>
	<i>Conjoint analysis</i>	<i>Cross Impact analysis</i>	<i>SMIC Prob Expert</i>	<i>Trend extrapolation</i>	<i>Prediction markets</i>	<i>(Modeling & simulations)</i>	<i>Scenario discovery</i>		<i>Life cycle an. / sustainability</i>				
	<i>Social network analysis</i>	<i>State of the future</i>	<i>Scientometrics</i>	<i>Trend impact analysis</i>		<i>(Decision modeling)</i>							
	<i>Social Software (Webometrics)</i>	<i>Conjoint analysis</i>		<i>S-curves</i>		<i>(Robust Decision Making)</i>							
		<i>Social network analysis</i>		<i>Technology substitution</i>		<i>System dynamics</i>							
		<i>Social Software (Almetrics)</i>		<i>Megatrend analysis</i>									
				<i>Time series / Indicators</i>									
				<i>Google trends & correlate</i>									

Source: our own elaboration based on Porter (2010) (see Sections 3.1 and B)

Table 1: *Classification of techniques. Quantitative techniques are divided into 10 different groups (in bold). The groups/techniques are ordered along the dimensions indicated on top of the table. In italic are the techniques that are new to FTA.*

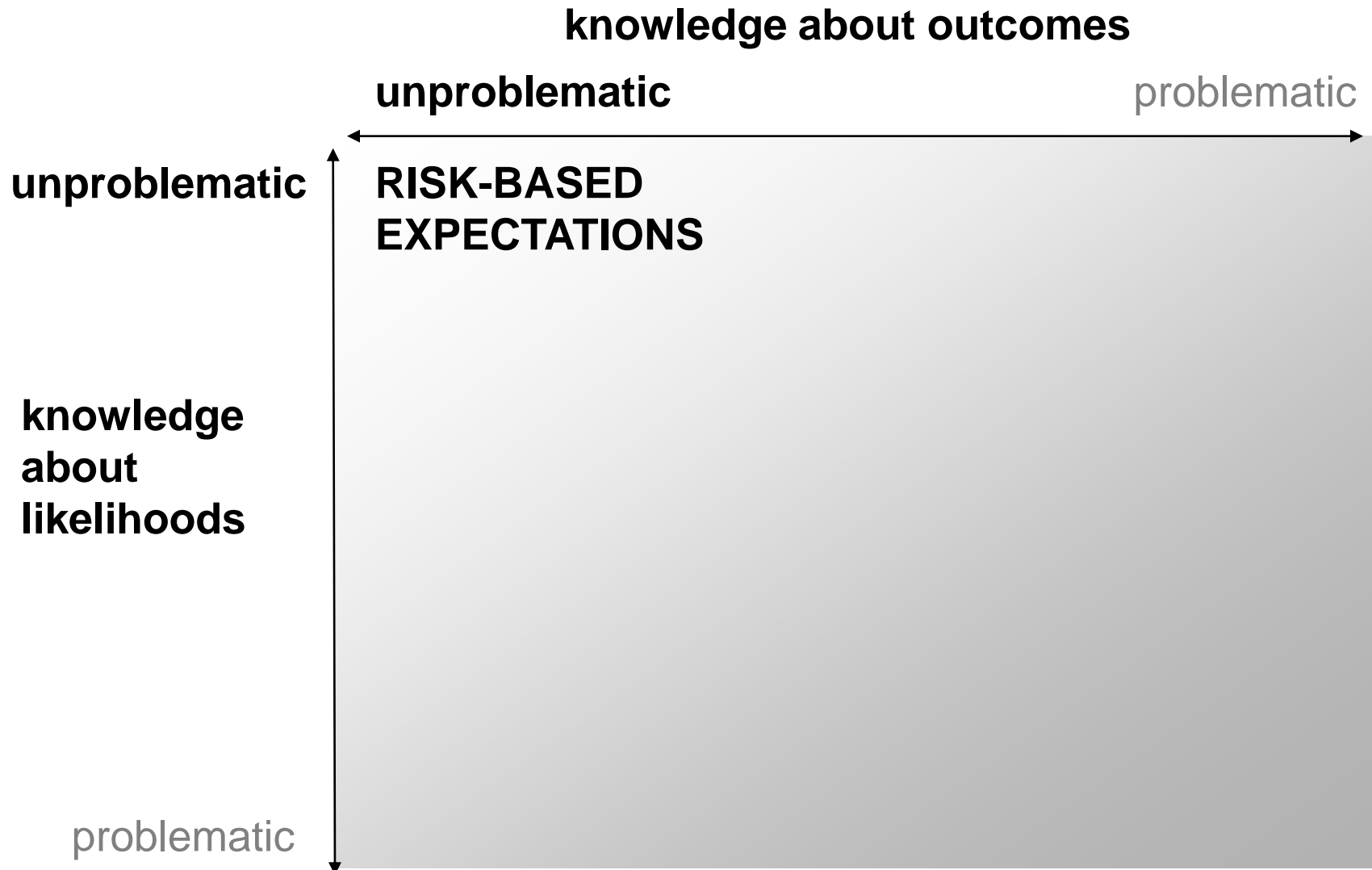
Future Technology Analysis

How is knowledge represented by users of FTA methods in terms of 'incertitude'?



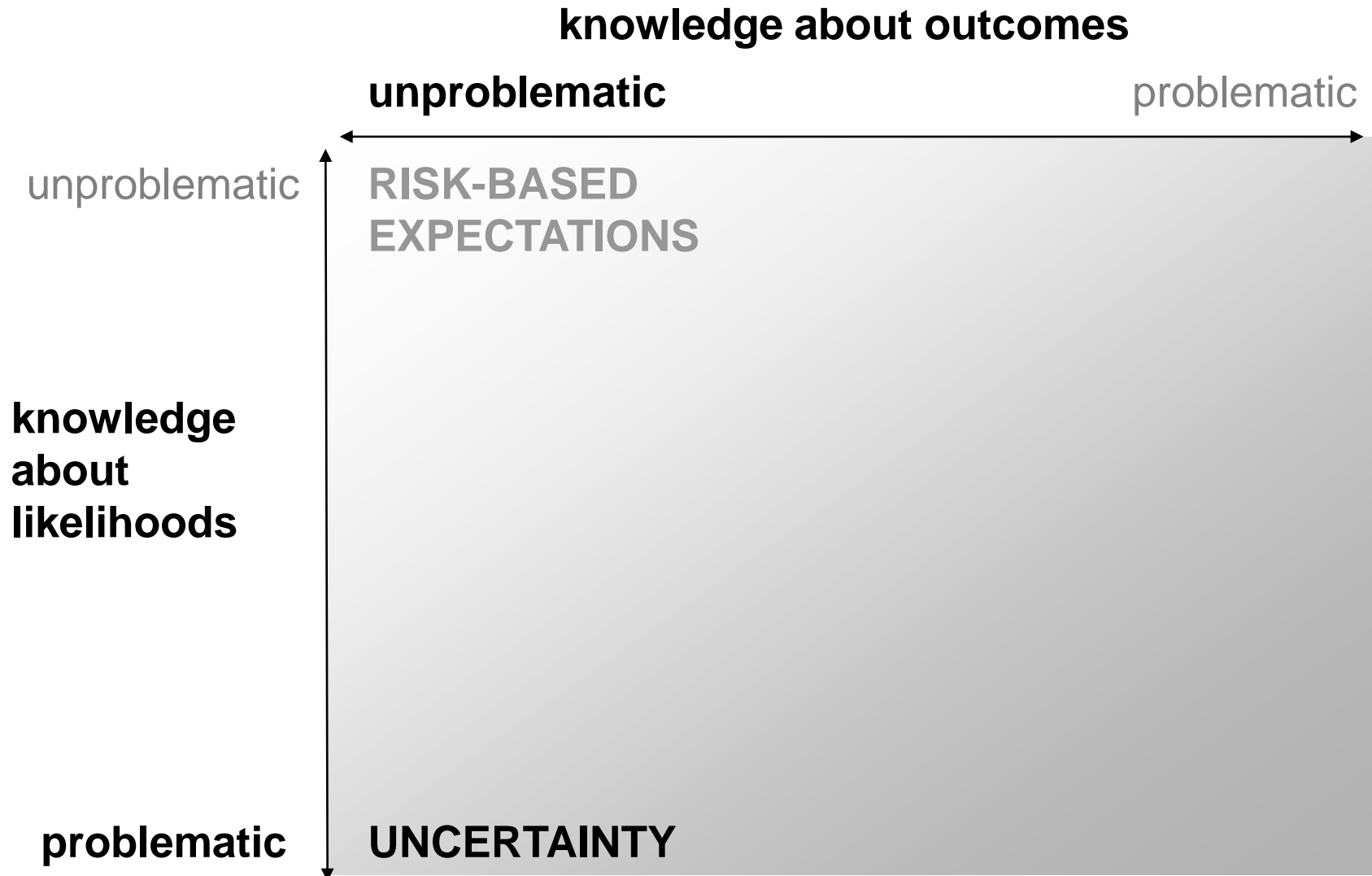
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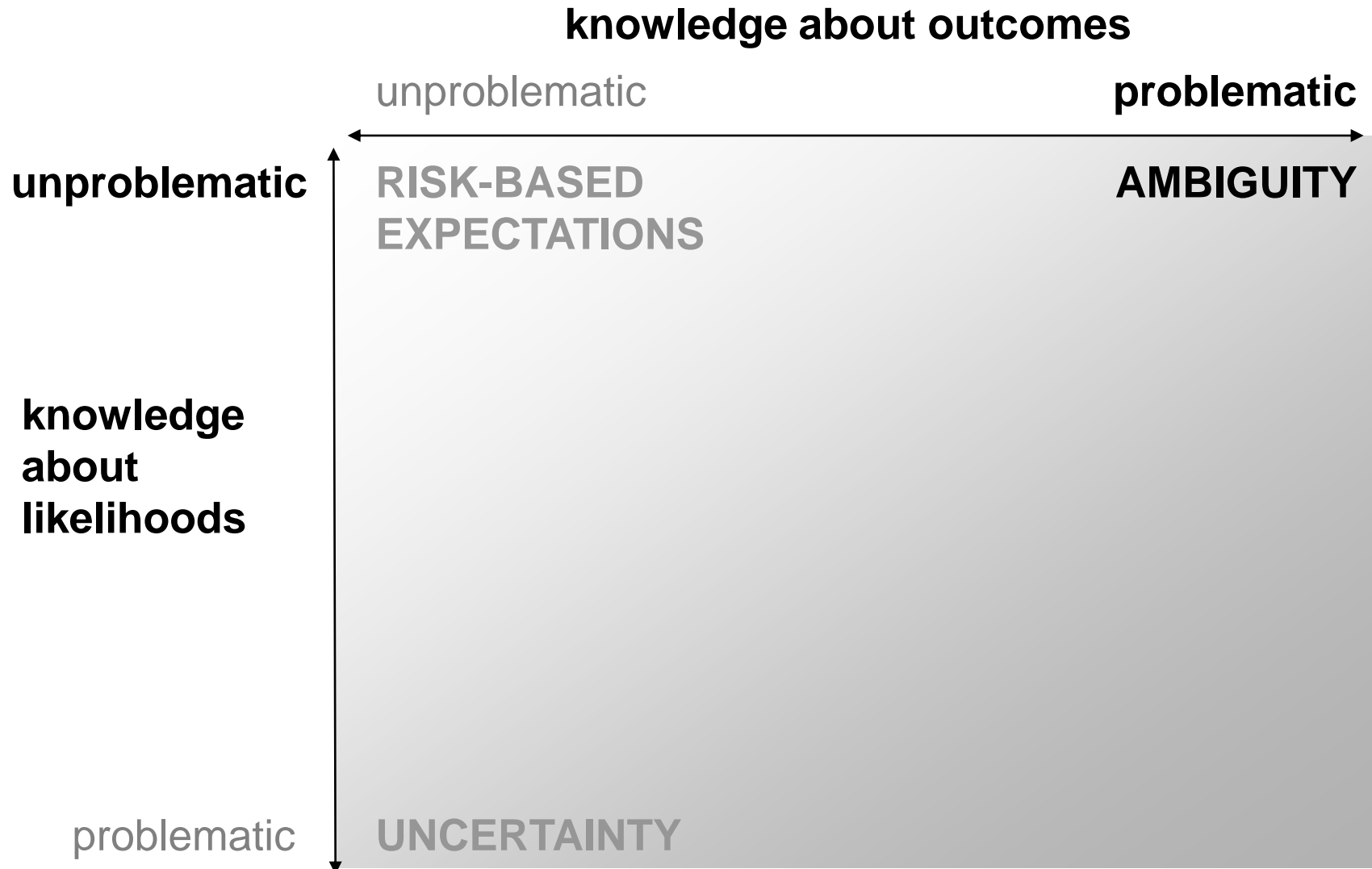
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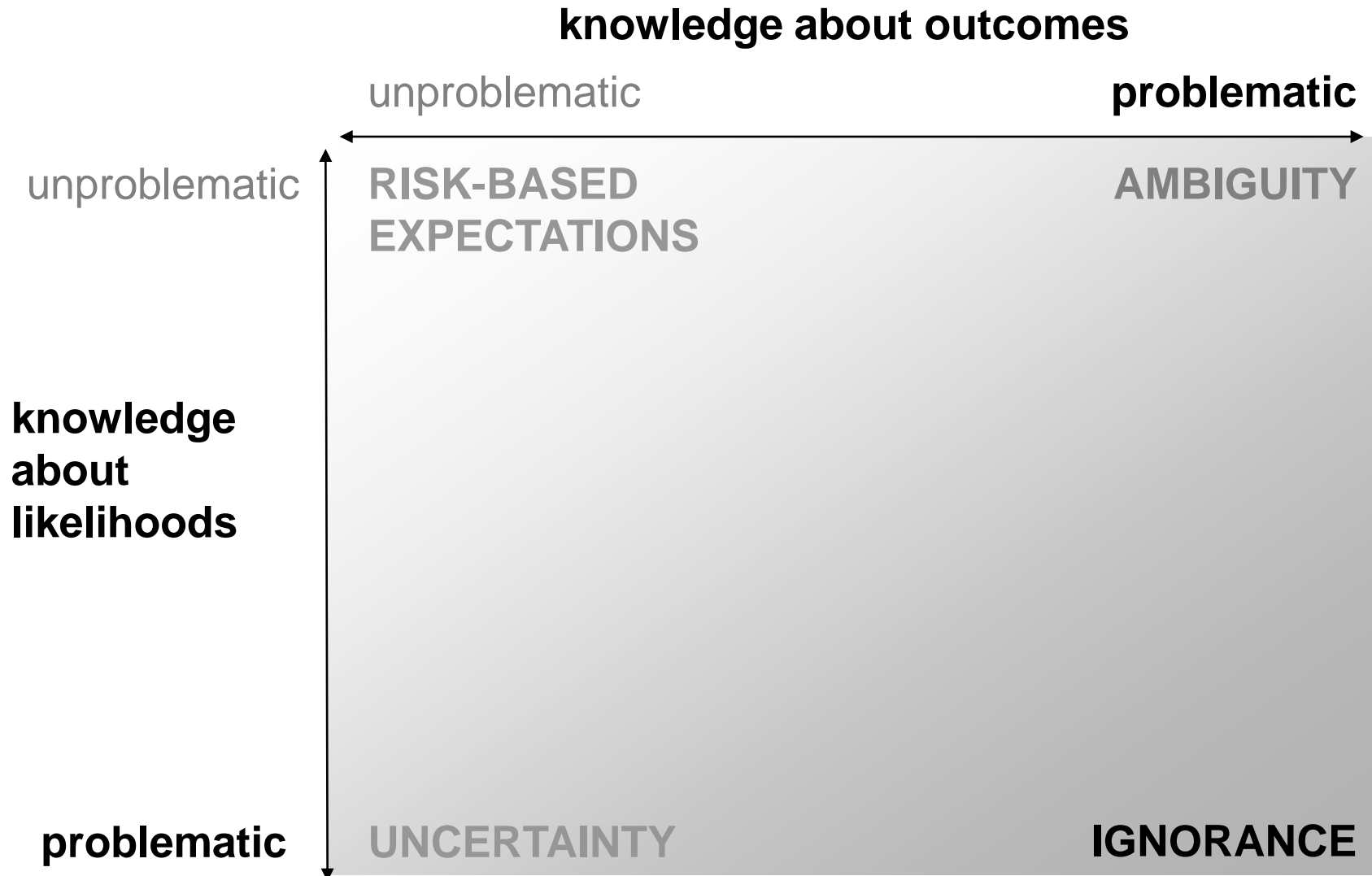
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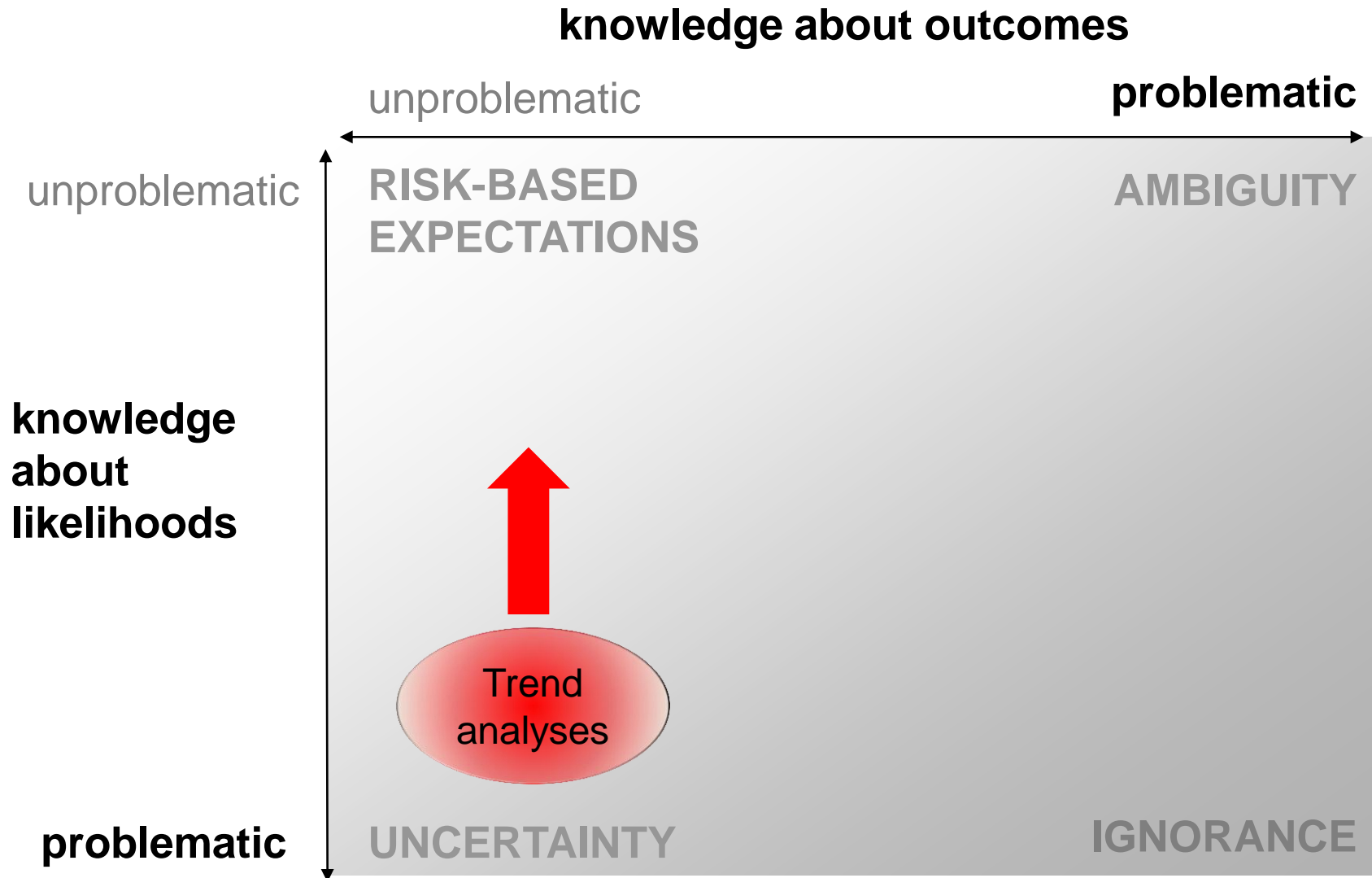
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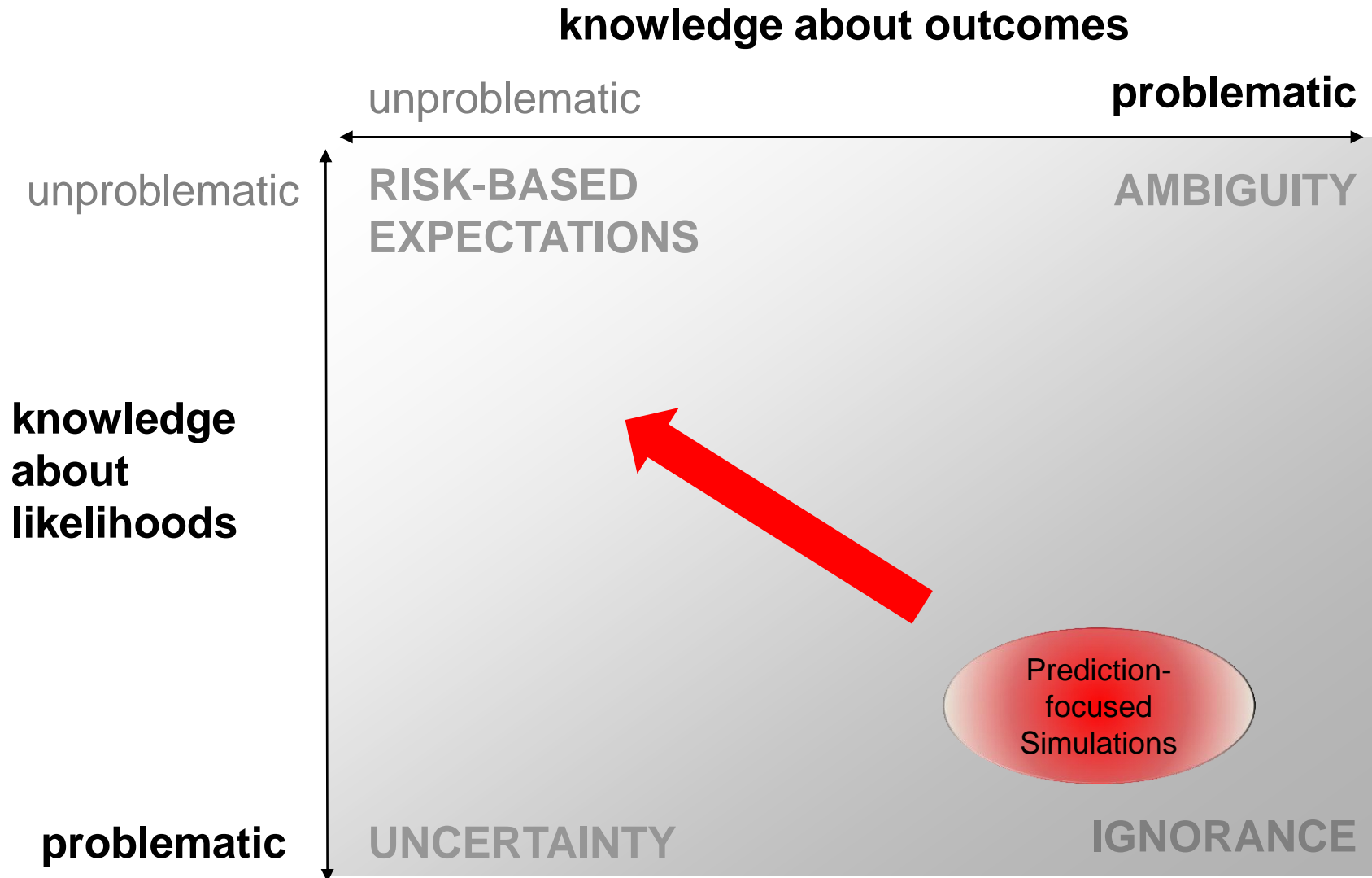
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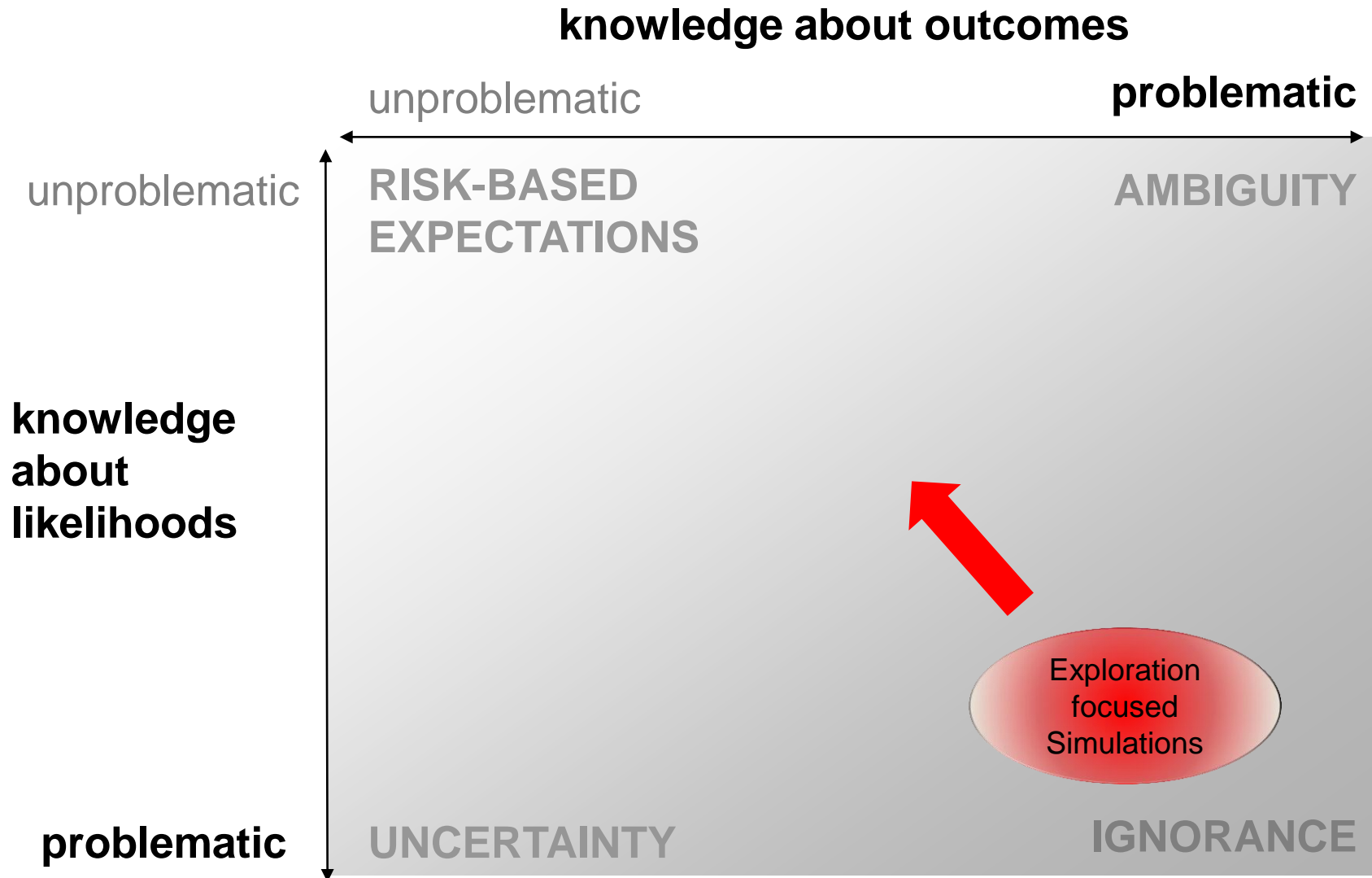
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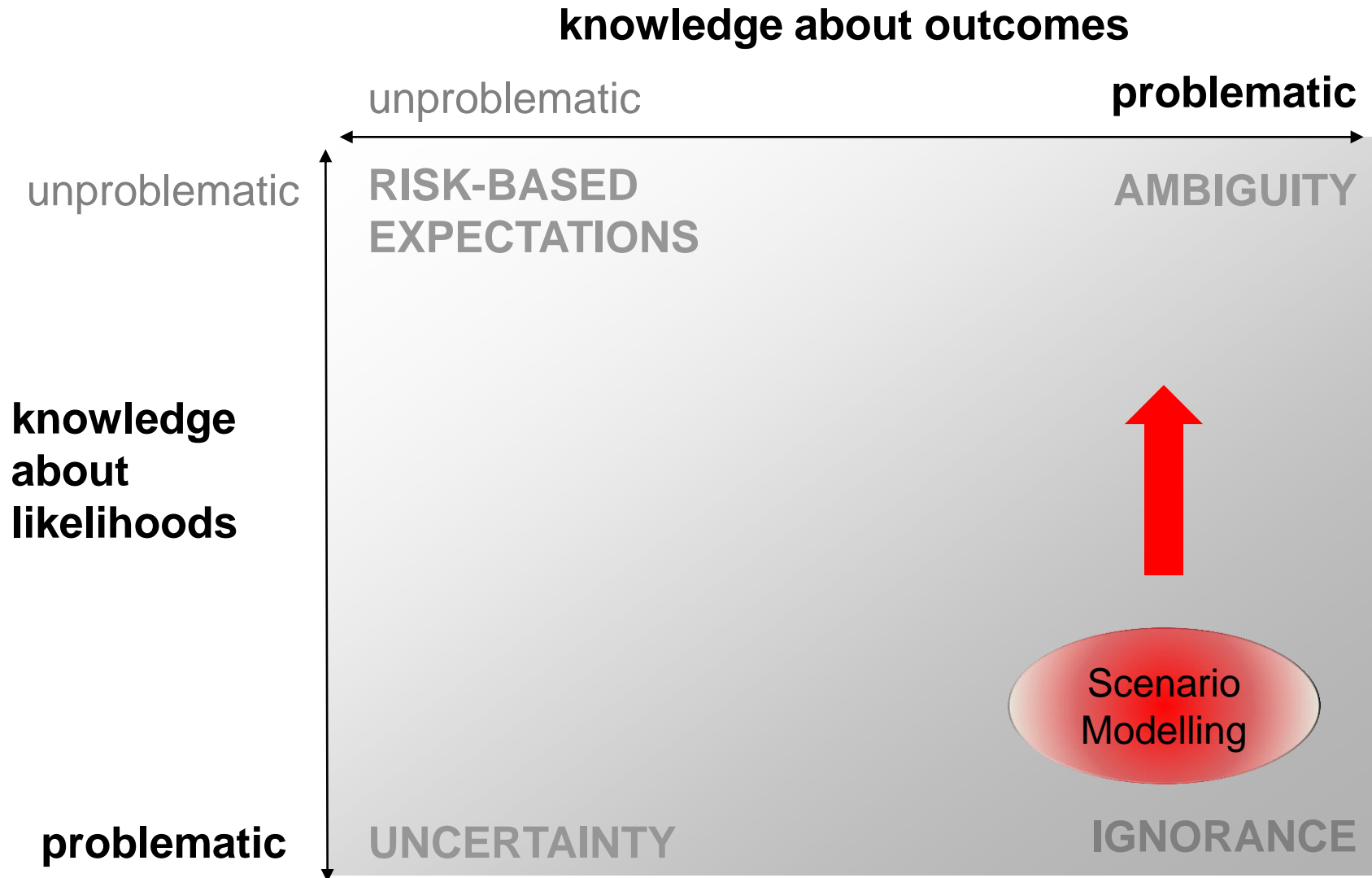
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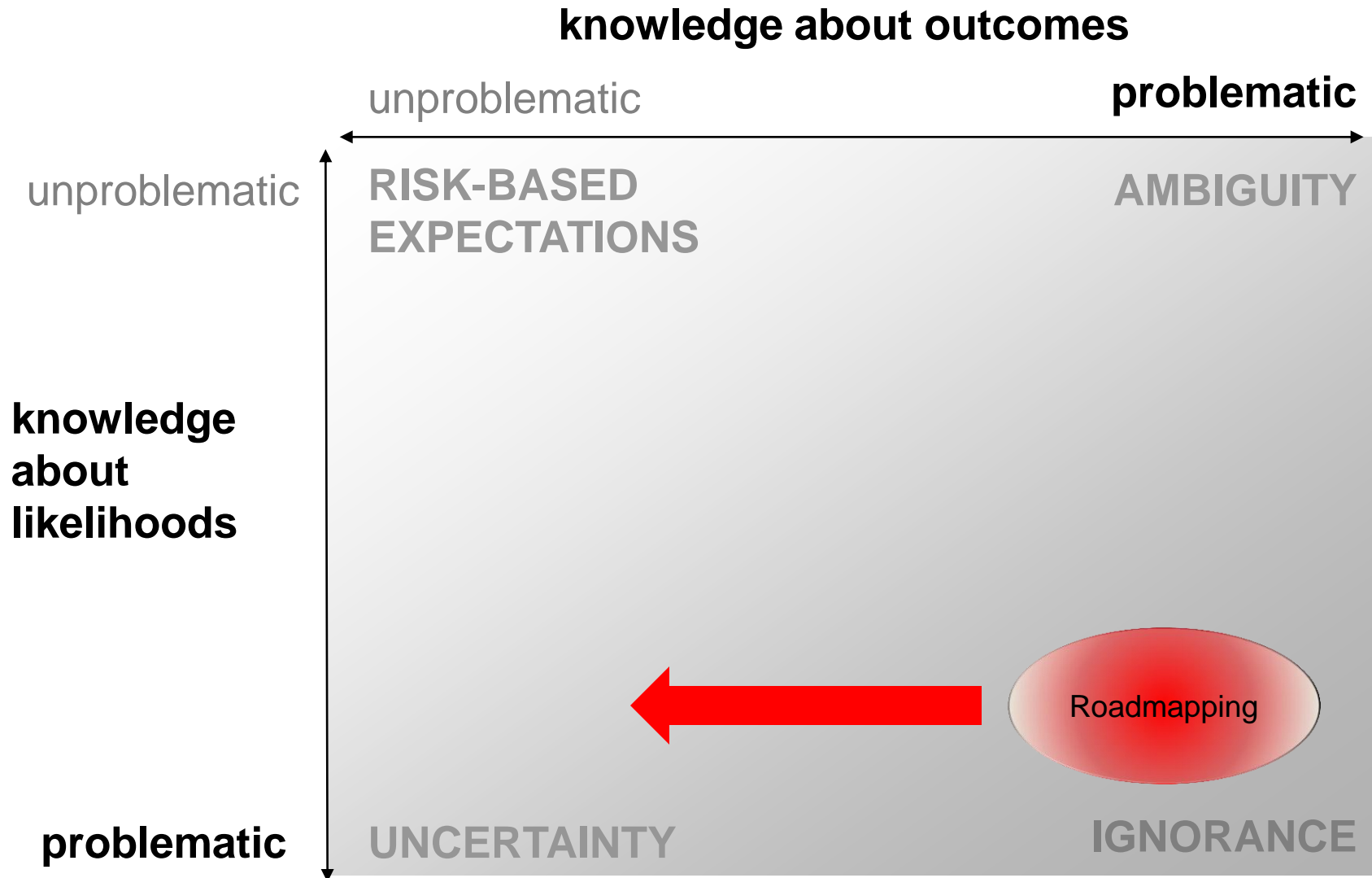
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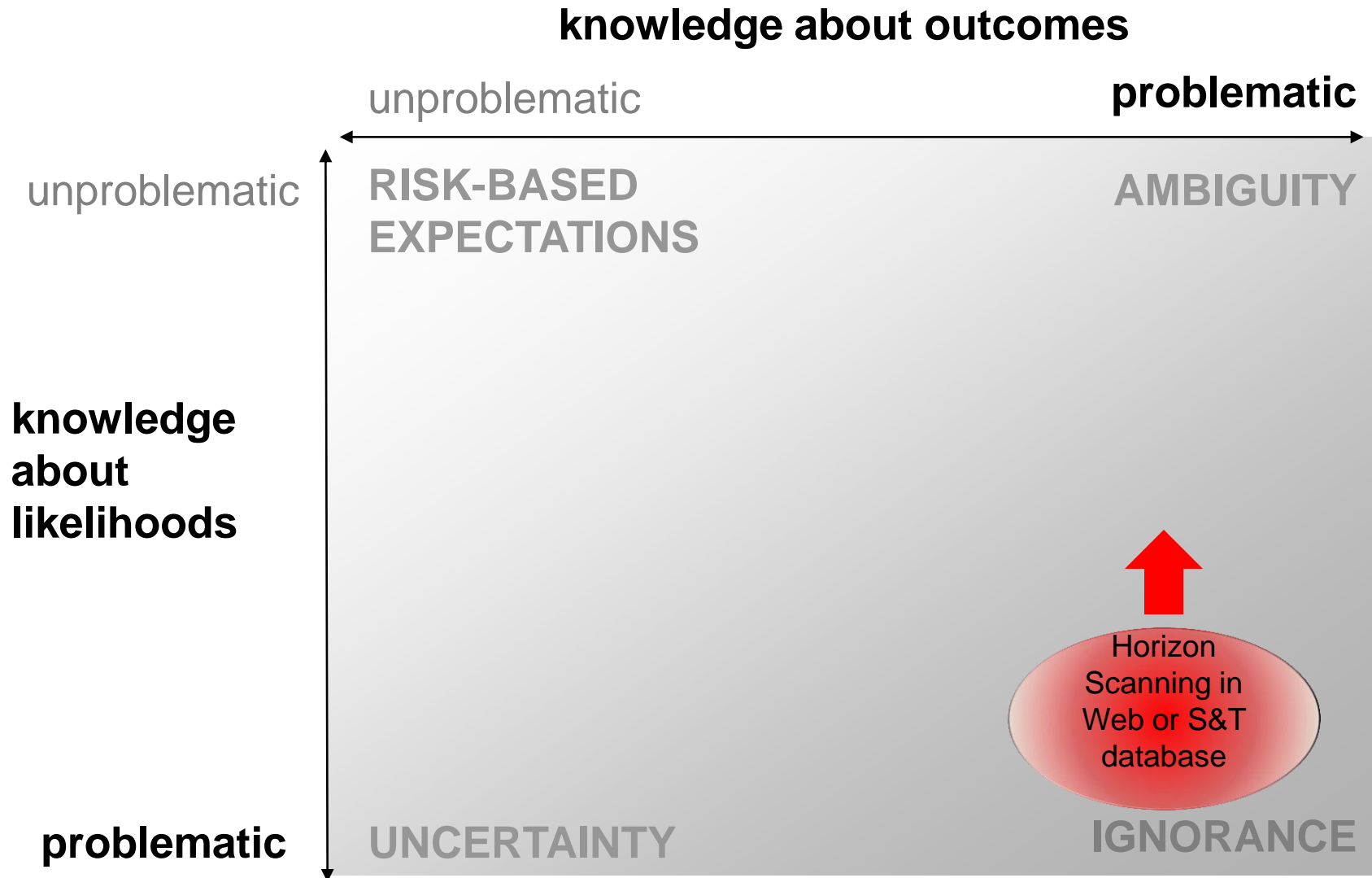
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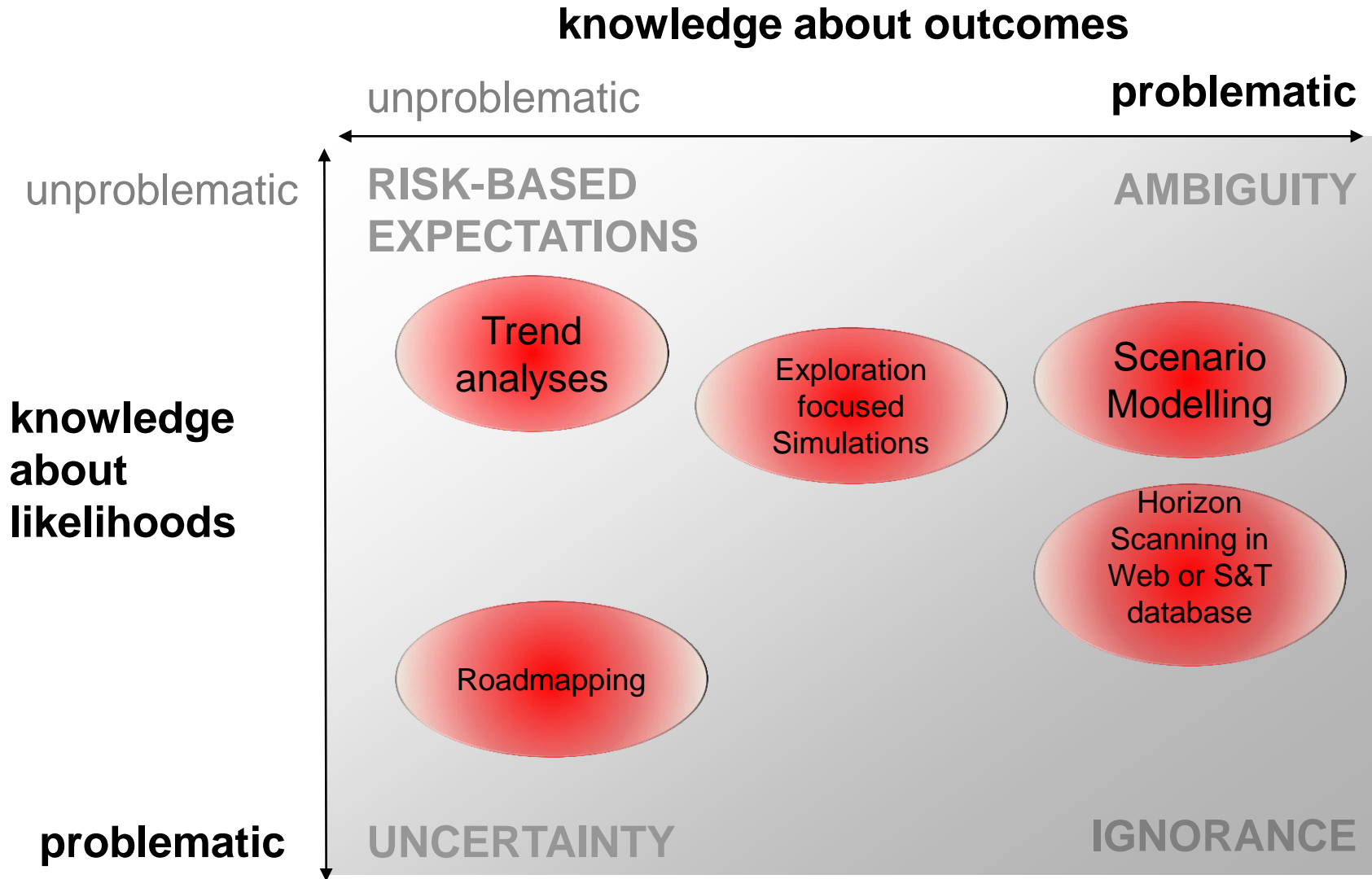
Future Technology Analysis

How is knowledge represented by users of FTA methods in terms of 'incertitude'?



Future Technology Analysis

How is knowledge represented by users of FTA methods in terms of 'incertitude'?



Closing down dynamics in FTA

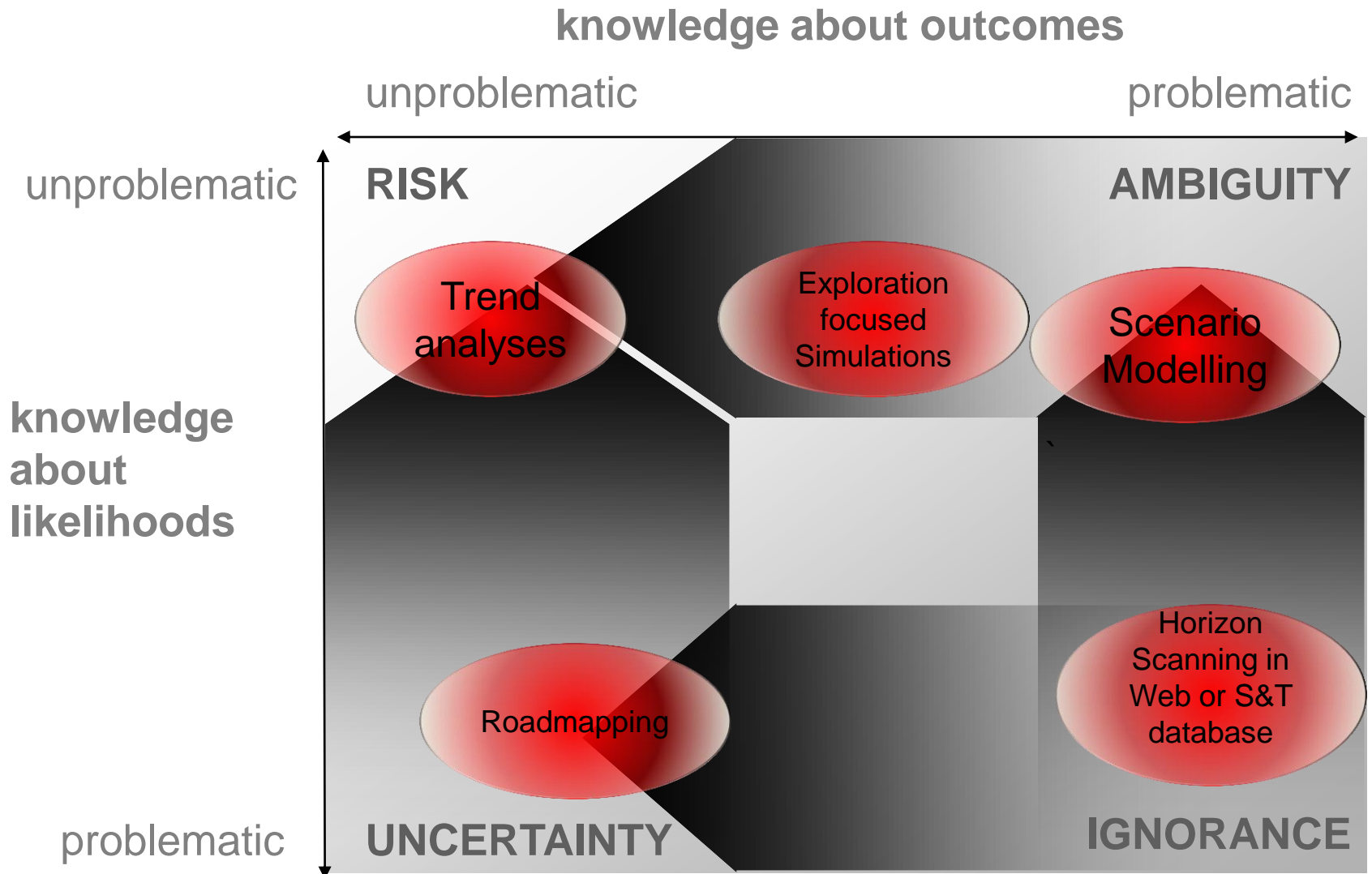
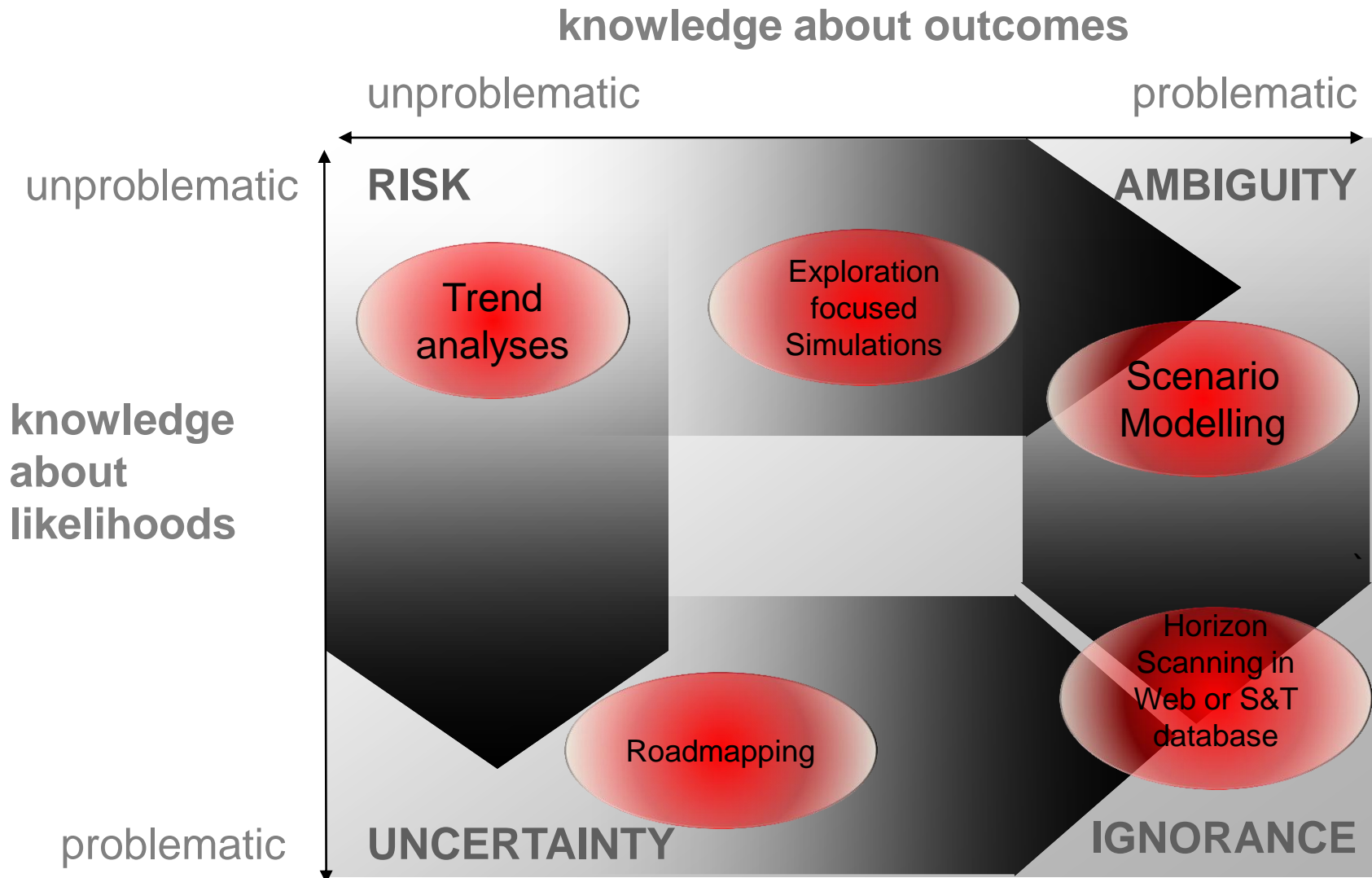


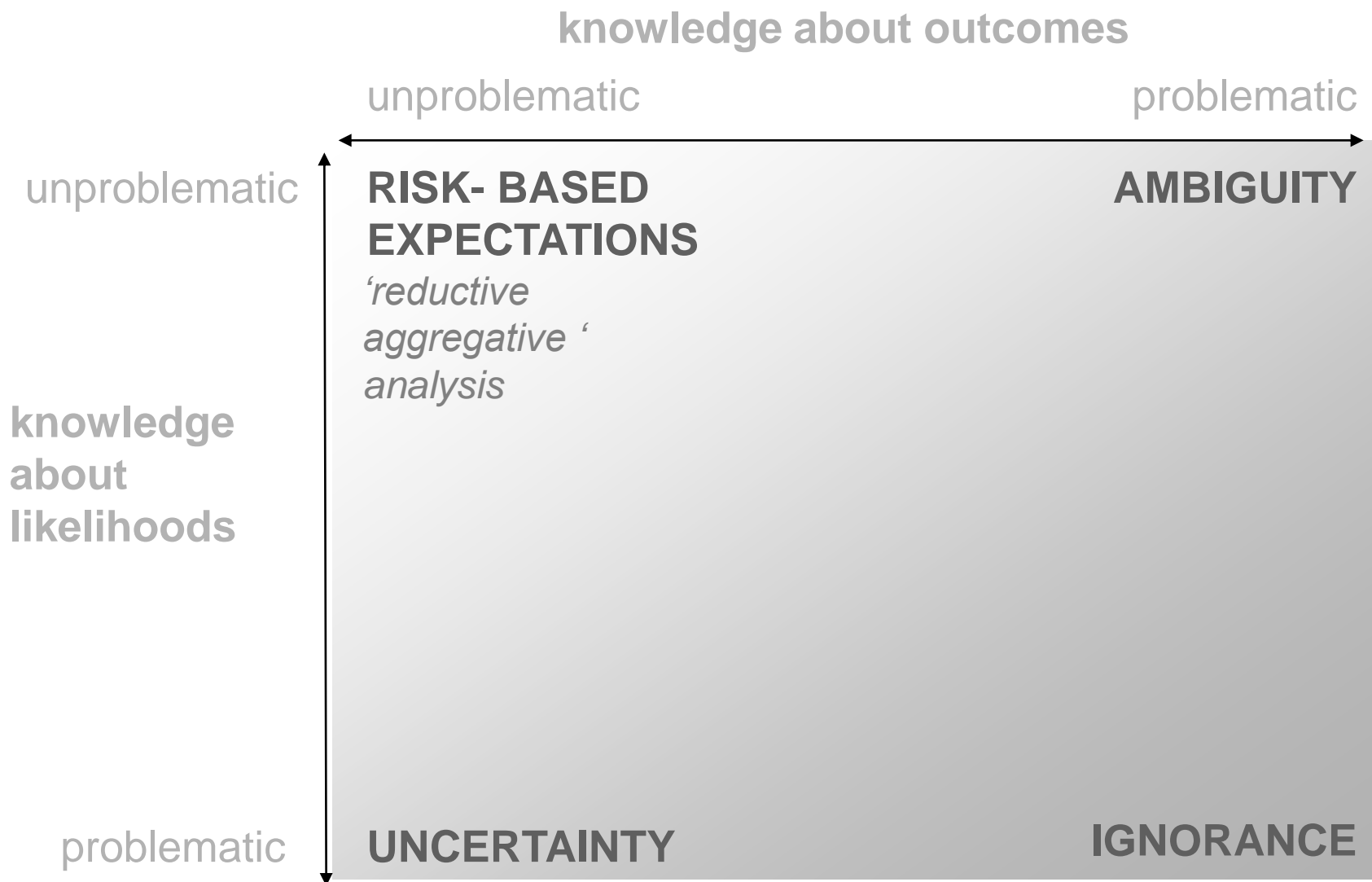
Figure borrowed from Stirling (2009)

Opening up dynamics in FTA



After Stirling (2009)

Forecasting vs. Foresight



Forecasting vs. Foresight

knowledge about outcomes

unproblematic

problematic

unproblematic

**RISK-BASED
EXPECTATIONS**

AMBIGUITY

*'reductive
aggregation
and
simplification'*

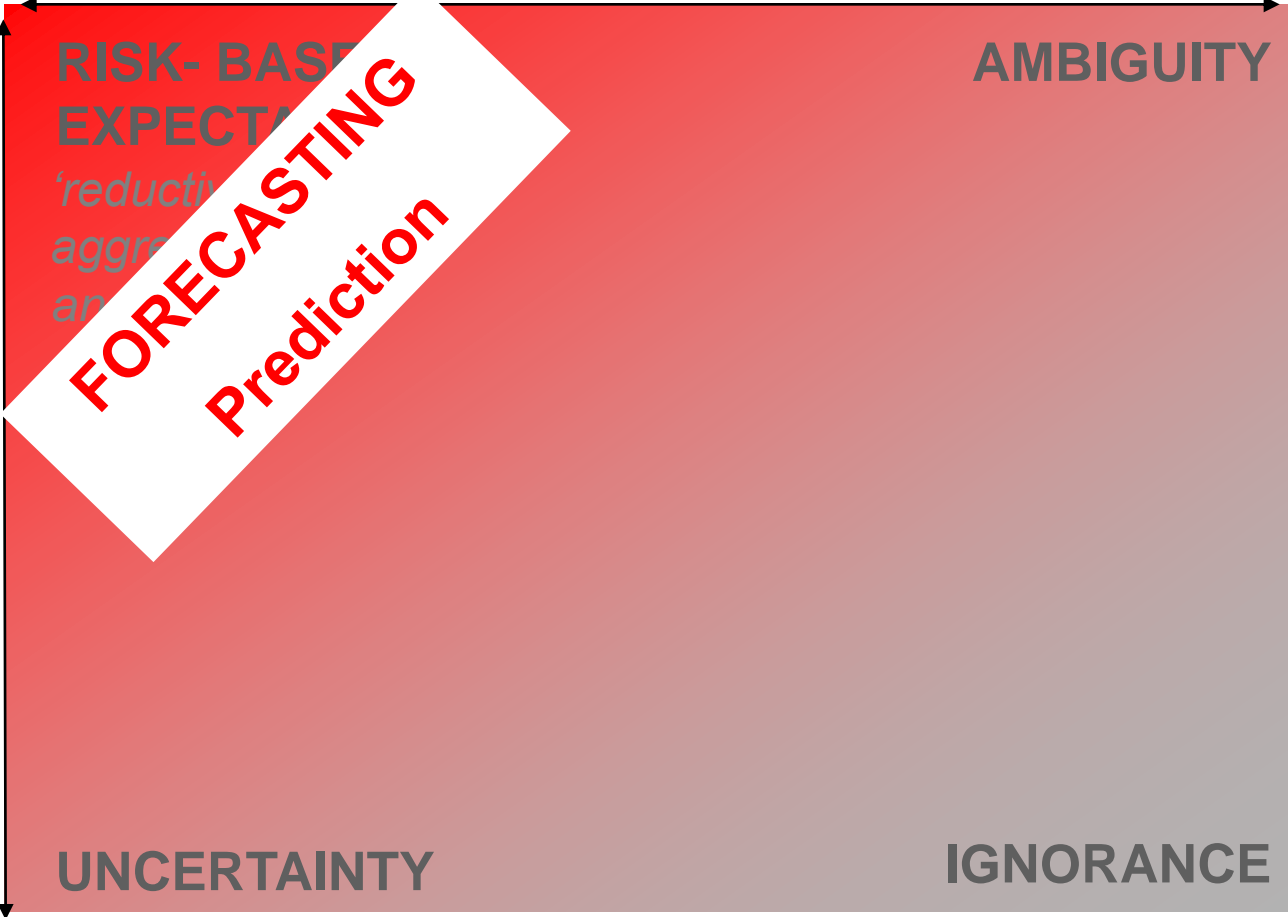
FORECASTING
Prediction

knowledge
about
likelihoods

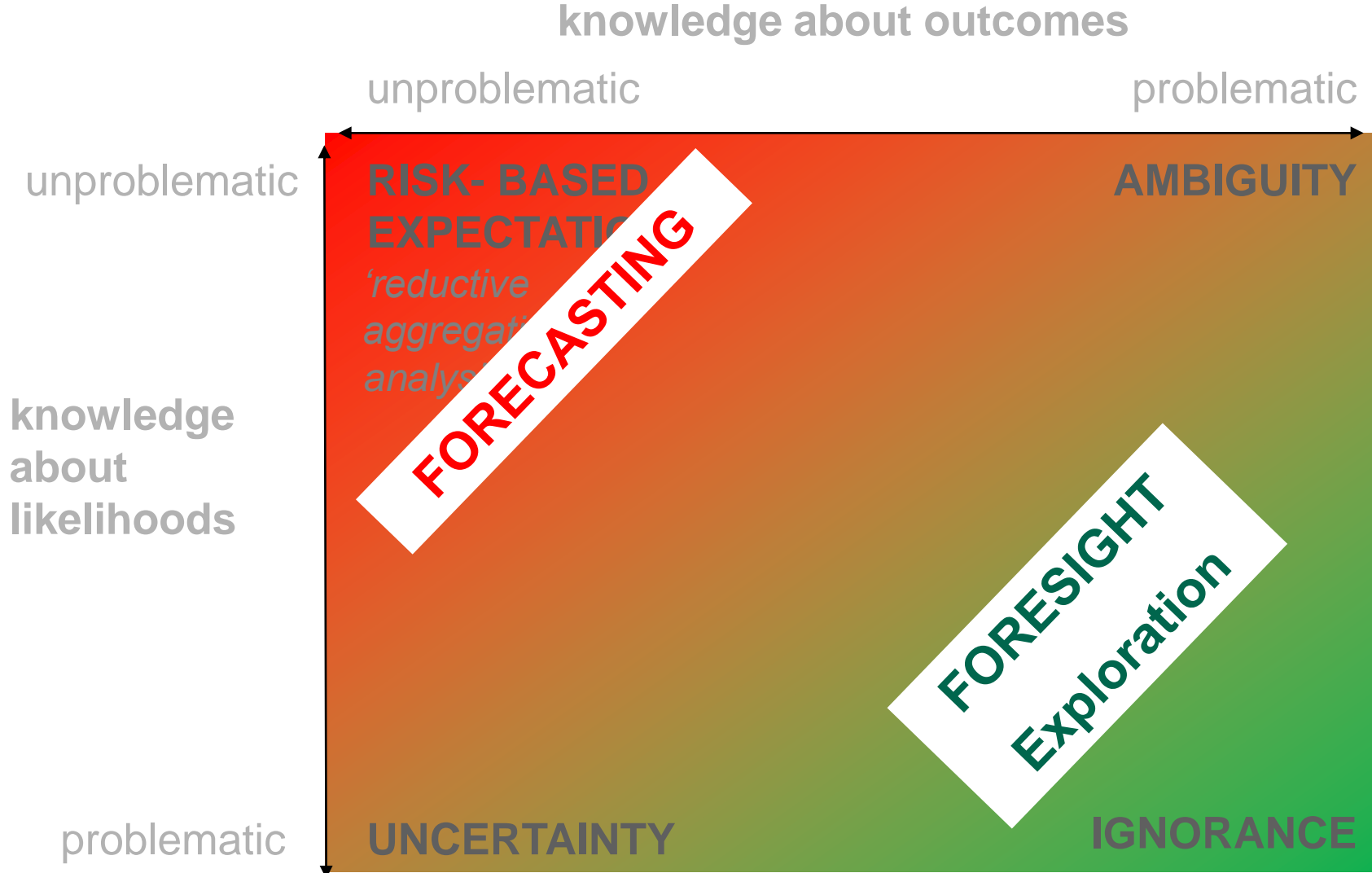
problematic

UNCERTAINTY

IGNORANCE

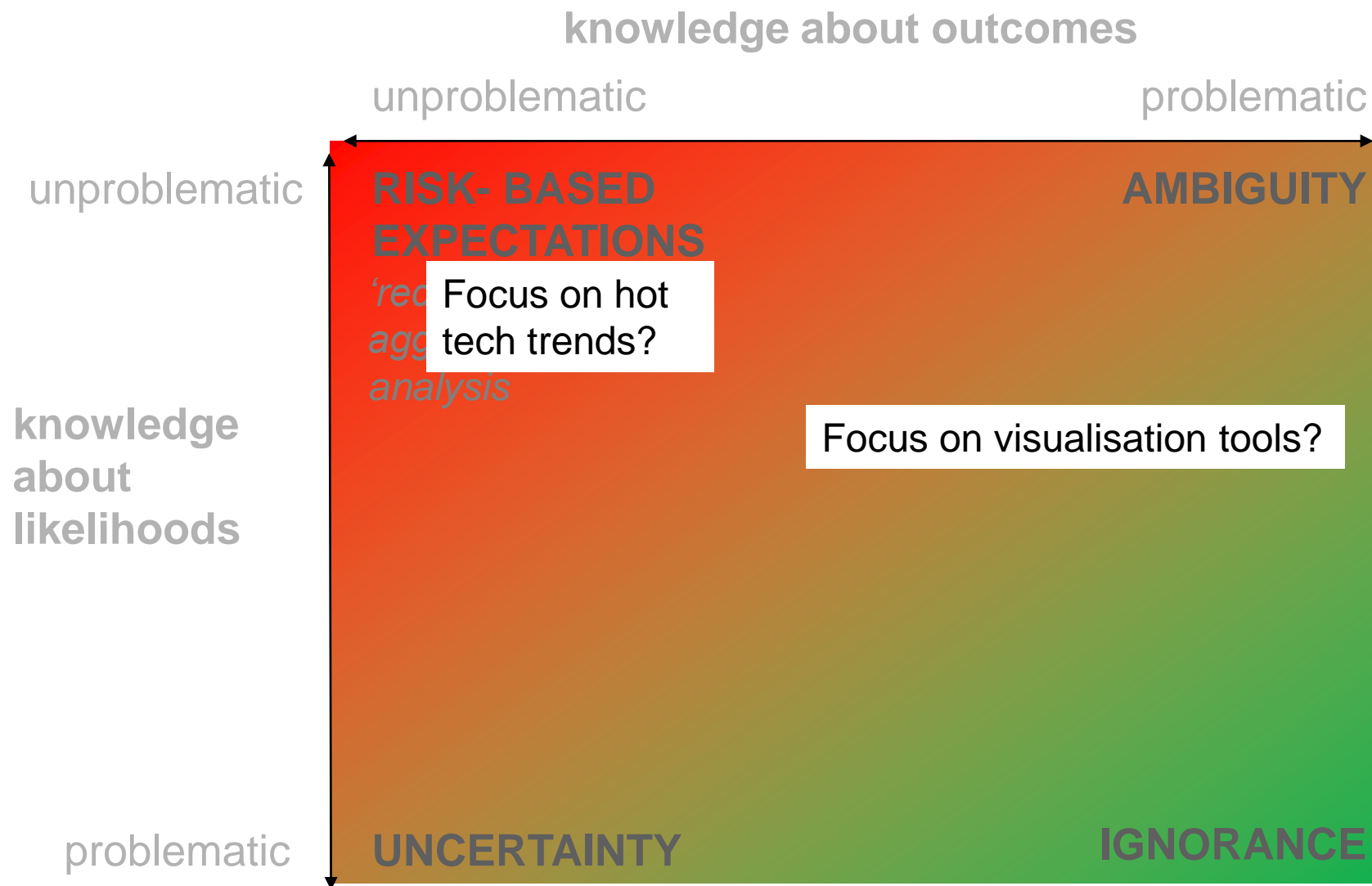


Forecasting vs. Foresight



Framework for the analysis on the use of new FTA tools?

- BIG DATA: large databases, web-scraping, etc.
- Potential for diverse types of analysis, both Opening up and Closing down.
- Tendency towards prediction-focusing approaches?



Heuristic framework on 'opening up' effect of quant FTAs

- Methods that “crunch” uncertainty and outcomes
 - Trend analyses, prediction markets,
- Methods that reduce outcomes
 - Roadmapping
- Methods that reduce mainly uncertainty
 - Some simulations, Scenario modelling
- Methods that explore ignorance
 - Monitoring methods (raw web-scraping): identify potential outcomes, but don't close down alternatives

Policy use of FTA: Appraisal

Appraisal:

‘the ensemble of processes through which knowledges are gathered and produced in order to inform decision-making and wider institutional commitments’ Leach et al. (2008)

Breadth: extent to which appraisal covers diverse dimensions of knowledge

Openness: degree to which outputs provide an array of options for policies.

Policy use of S&T indicators: Appraisal

Appraisal:

‘the ensemble of processes through which knowledges are gathered and produced in order to inform decision-making and wider institutional commitments’ Leach et al. (2010)

Example:

Allocation of resources based on research excellence

Breadth: extent to which appraisal covers diverse dimensions of knowledge

Narrow: citations/paper

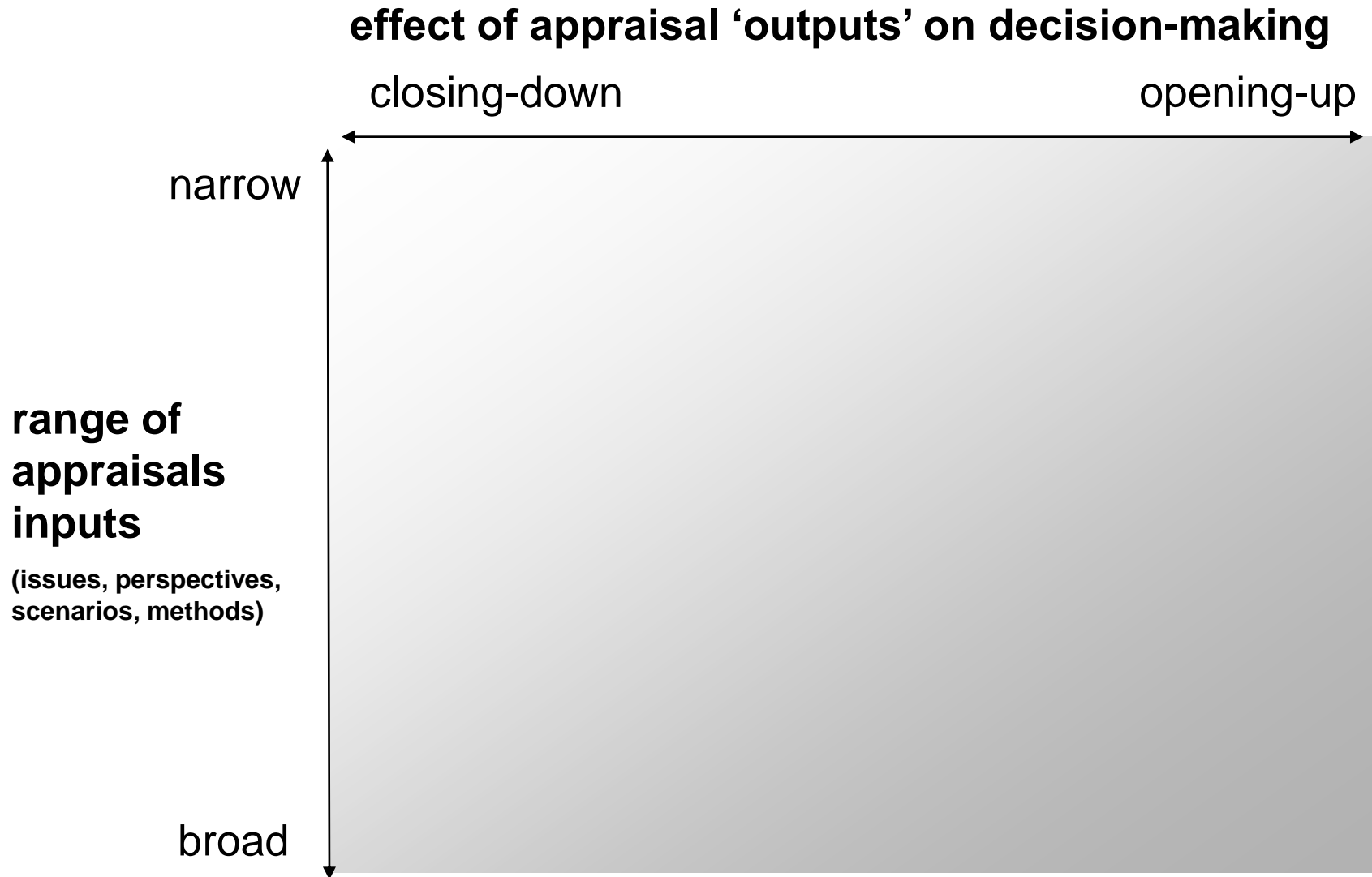
Broad: citations, peer interview, stakeholder view, media coverage, altmetrics

Openness: degree to which outputs provide an array of options for policies.

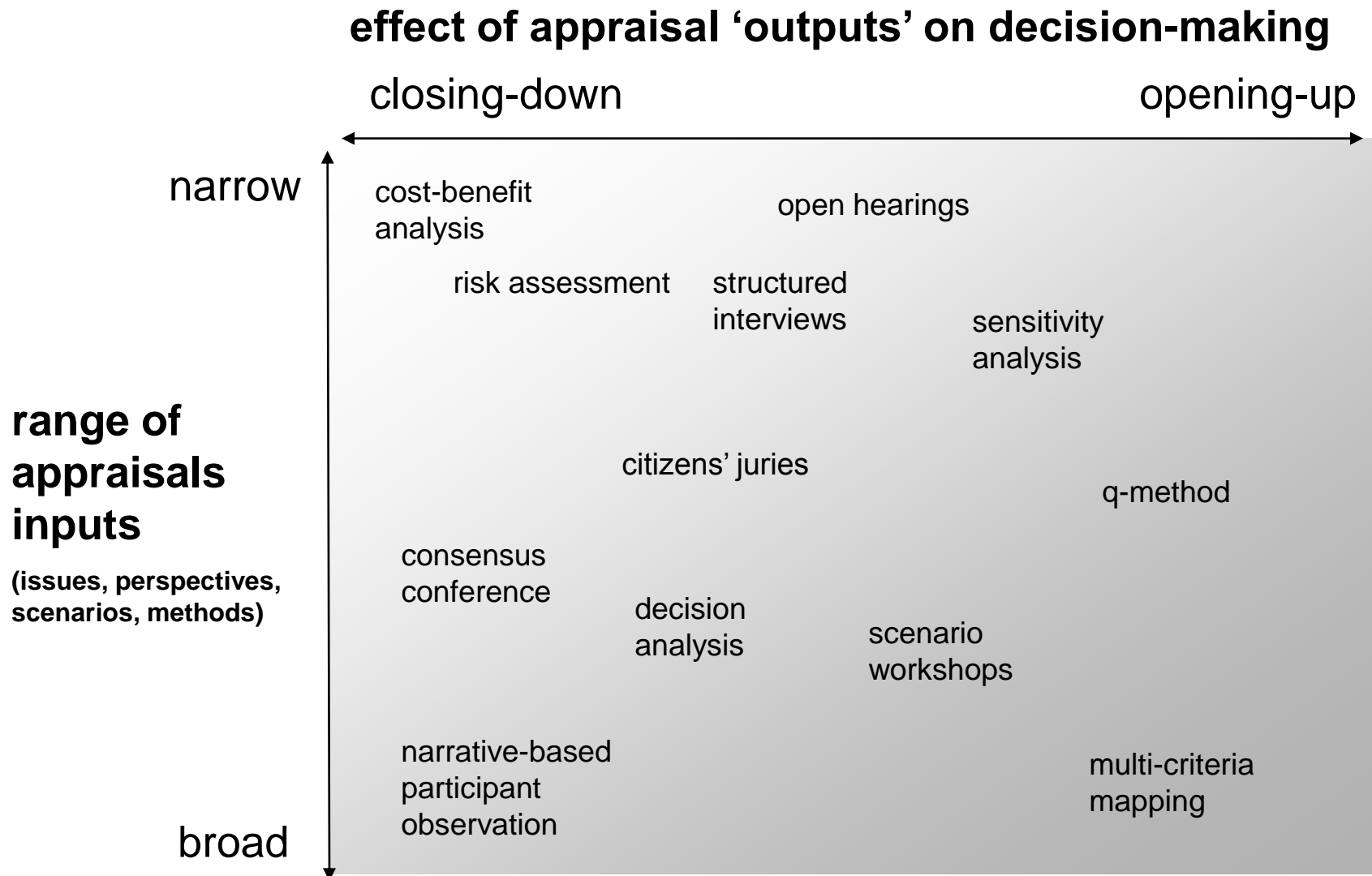
Closed: fixed composite measure of variables → unitary and prescriptive

Open: consideration of various dimensions → plural and conditional

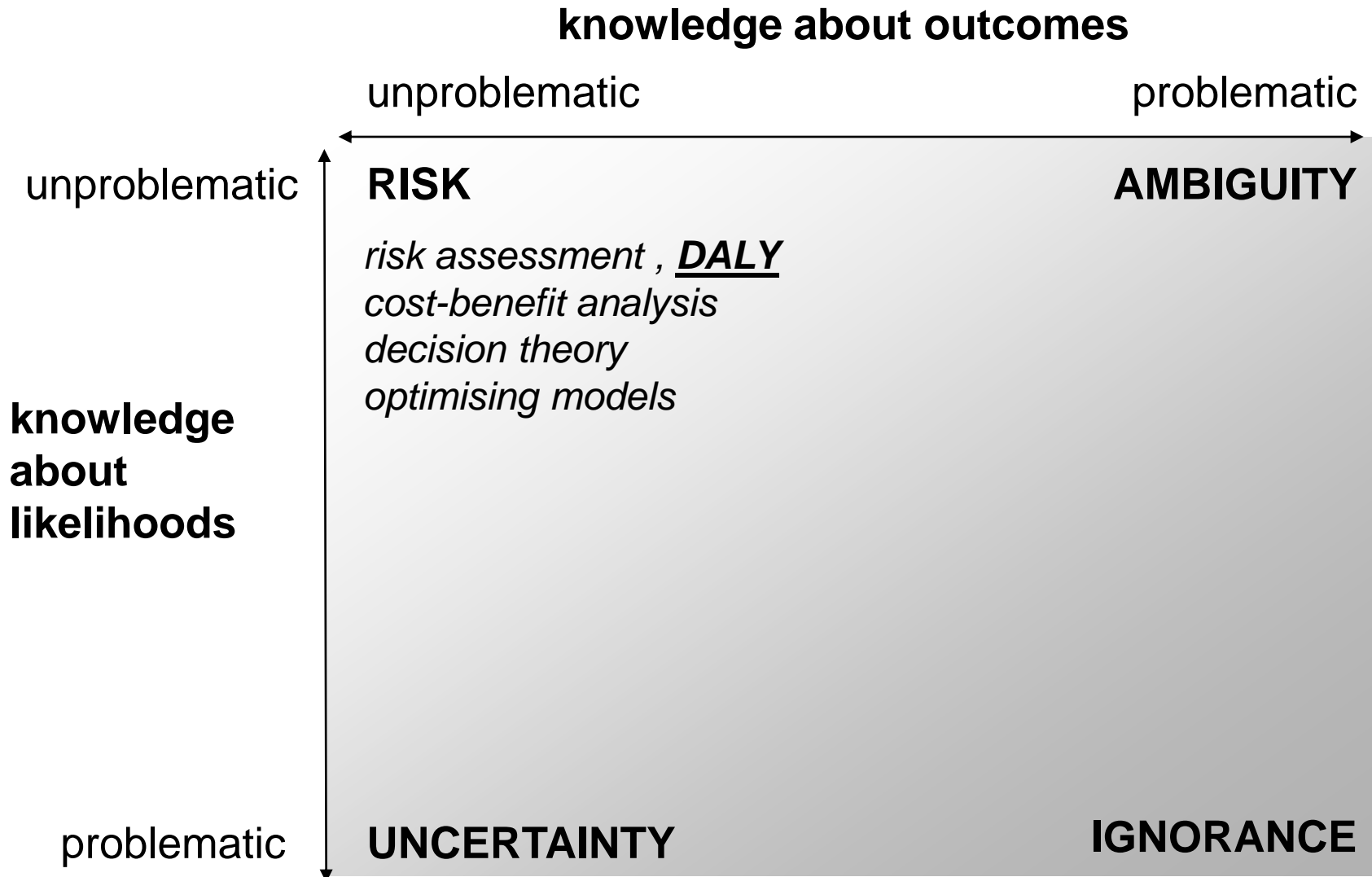
Appraisal methods: broad vs. narrow & close vs. open



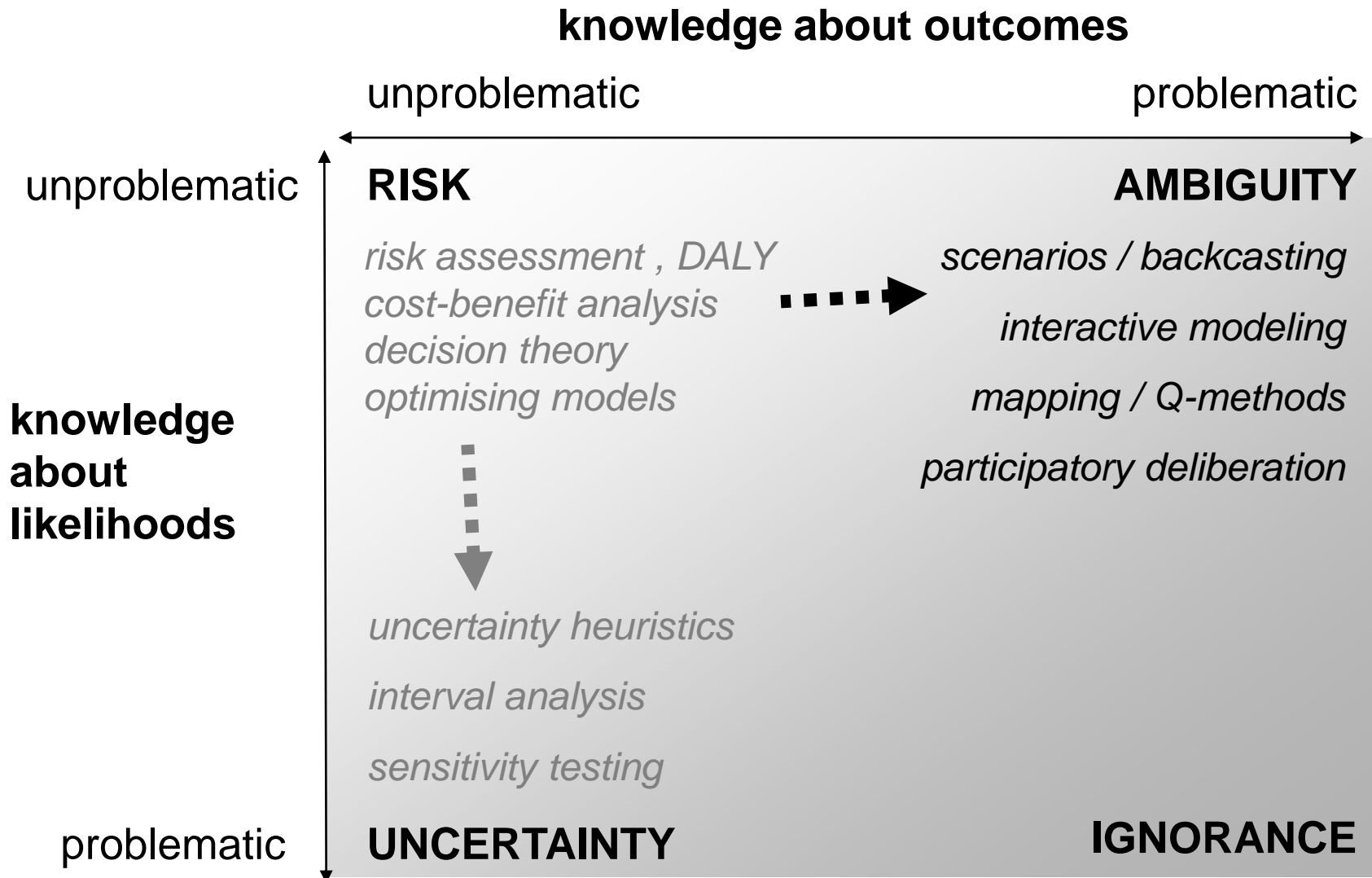
Appraisal methods: broad vs. narrow & close vs. open



Methodological Responses

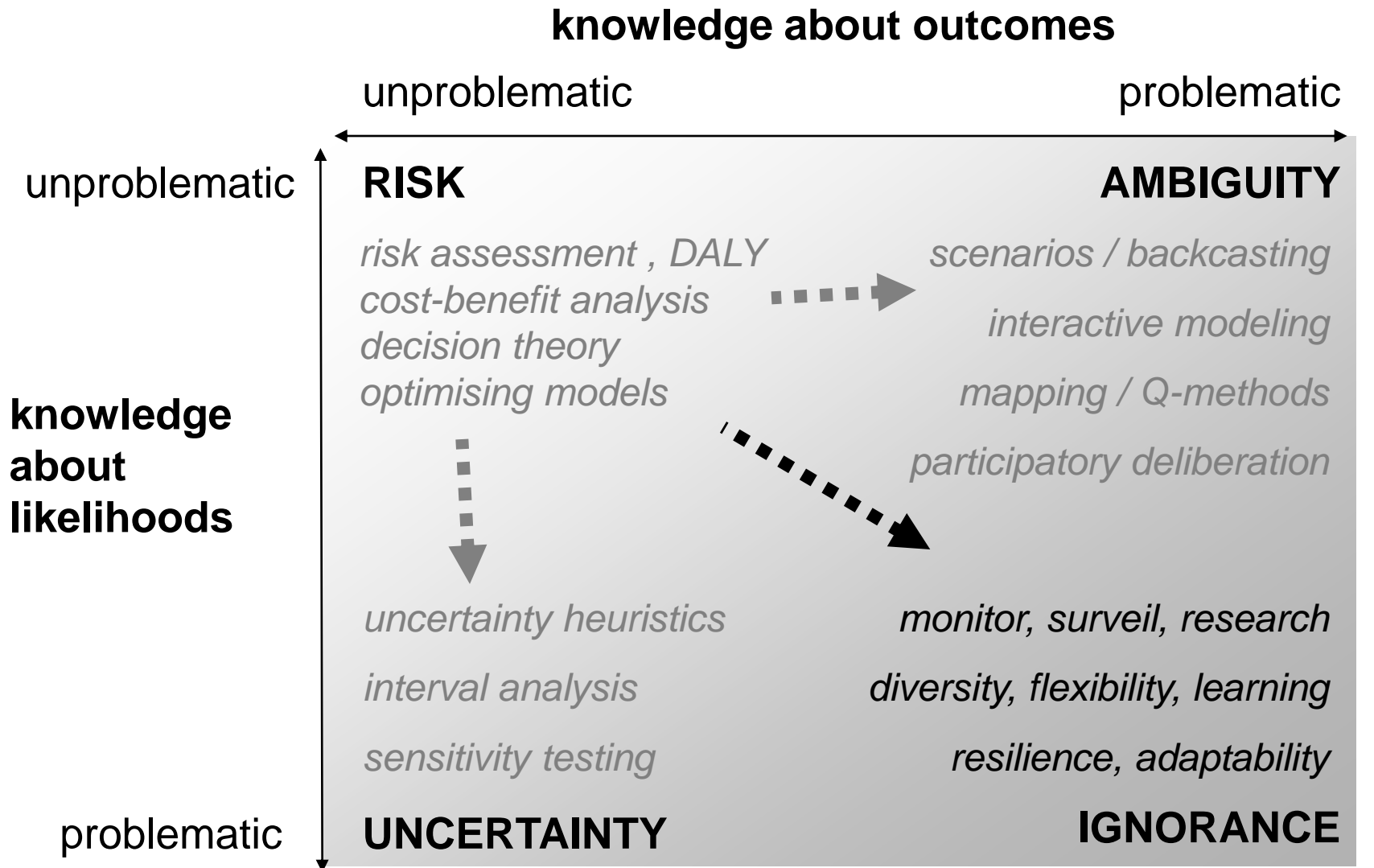


Methodological Responses



Scientists know but neglect in policy; media is especially reluctant to acknowledge

Methodological Responses



ALL INVOLVE GREATER HUMILITY OVER SUFFICIENCY OF KNOWLEDGE

Beyond Sound Science / Perception Dichotomy

precaution and participation are about rigour under incertitude

