Dealing with Uncertainty in Risk and Decision Analysis

Simon French

simon.french@warwick.ac.uk

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Who am I?

Simon French

- Mathematics background
- Bayesian Statistics and Decision Theory
- Decision Analysis
- Chernobyl Project
- Development of RODOS
- DH: Risk Management and communication
- Food safety and FSA
- Emergency Management

My Road to 'Damascus'

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System 1 and System 2 Thinking

- **System 1**
  - 'intuition' or 'gut reaction'
  - superficial analysis/interpretation of the relevant information
  - based on much simpler forms of thinking on the fringes or outside of consciousness. ⇒ **FAST**
- **System 2**
  - conscious analytical thought
  - detailed evaluation of a broad range of information . ⇒ **SLOW**
  - often based on a rule that is assumed to provide the 'correct' answer or solution;
  - Note System 2 does not mean forgetting emotions and values.

Who am I?

Simon French

- Mathematics background
- Developing System 2 Thinking
- Decision Analysis
- Chernobyl Project
- My Road to 'Damascus'
- Working with System 1 Thinking
- Emergency Management

Analytical

Practice

Prescriptive Decision Analysis

System 1: Descriptive Decision Studies

provide models of how people *do* make inferences and decisions

System 2: Normative Decision Theory

provide a model of how people *should* make inferences and decisions

Prescriptive Decision Analyses

seek to guide decision makers towards the ideals encoded by normative theories within the context of a real, often ill-defined problem, mindful of their cognitive characteristics

Science and Values

- Science – what might happen
  - seldom a single science view
  - subjective, controversy, debate
  - uncertainty
- Values – how much it matters if it does
  - subjective
  - often relate to intangibles
  - different stakeholder perspectives

Key questions in ‘messy’ decision making

- What are our concerns?
  - (lack of) understanding of world

SCIENCE

- What are we trying to achieve?
  - values & objectives

VALUES

- What might we do to achieve this/these?
  - actions/strategies
- What might happen out there?
  - uncertainties about external world
- What might result?
  - consequences

SCIENCE

- How much it matter if it does
  - impact

VALUES

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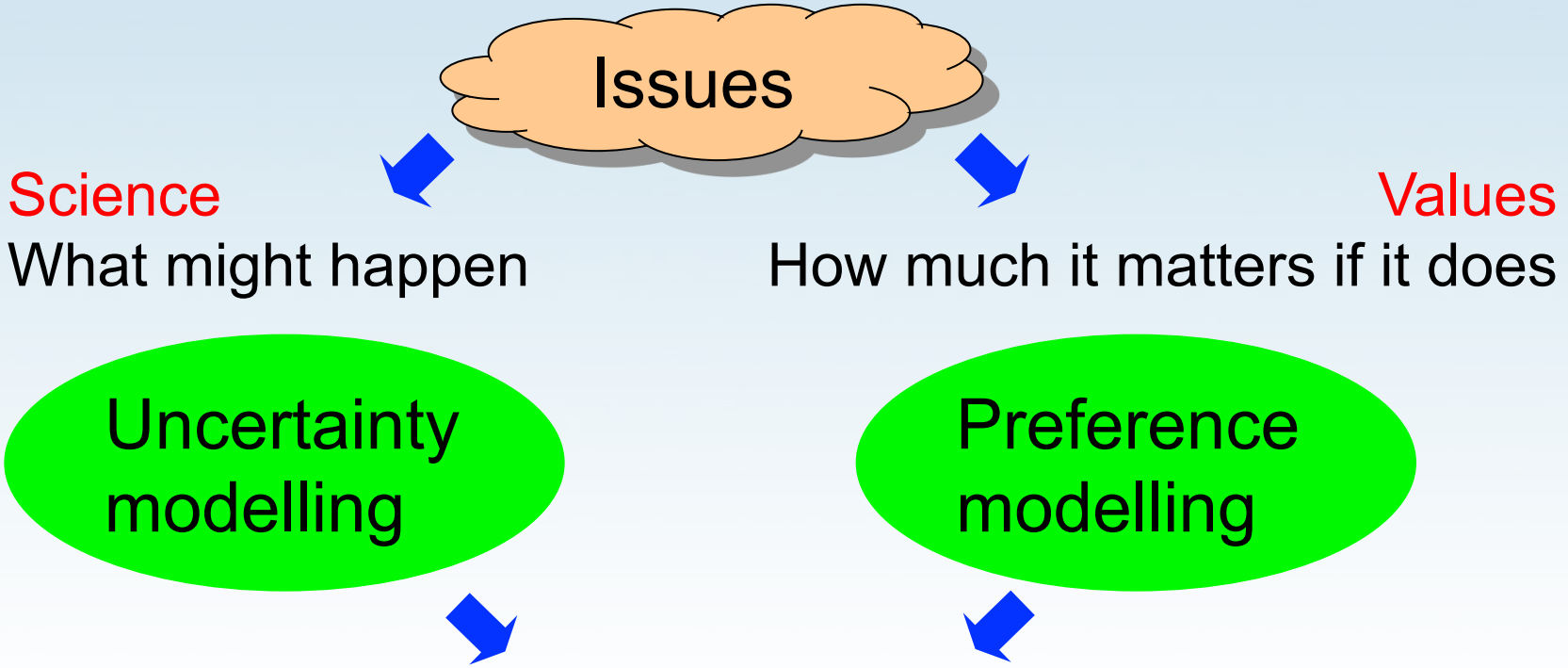
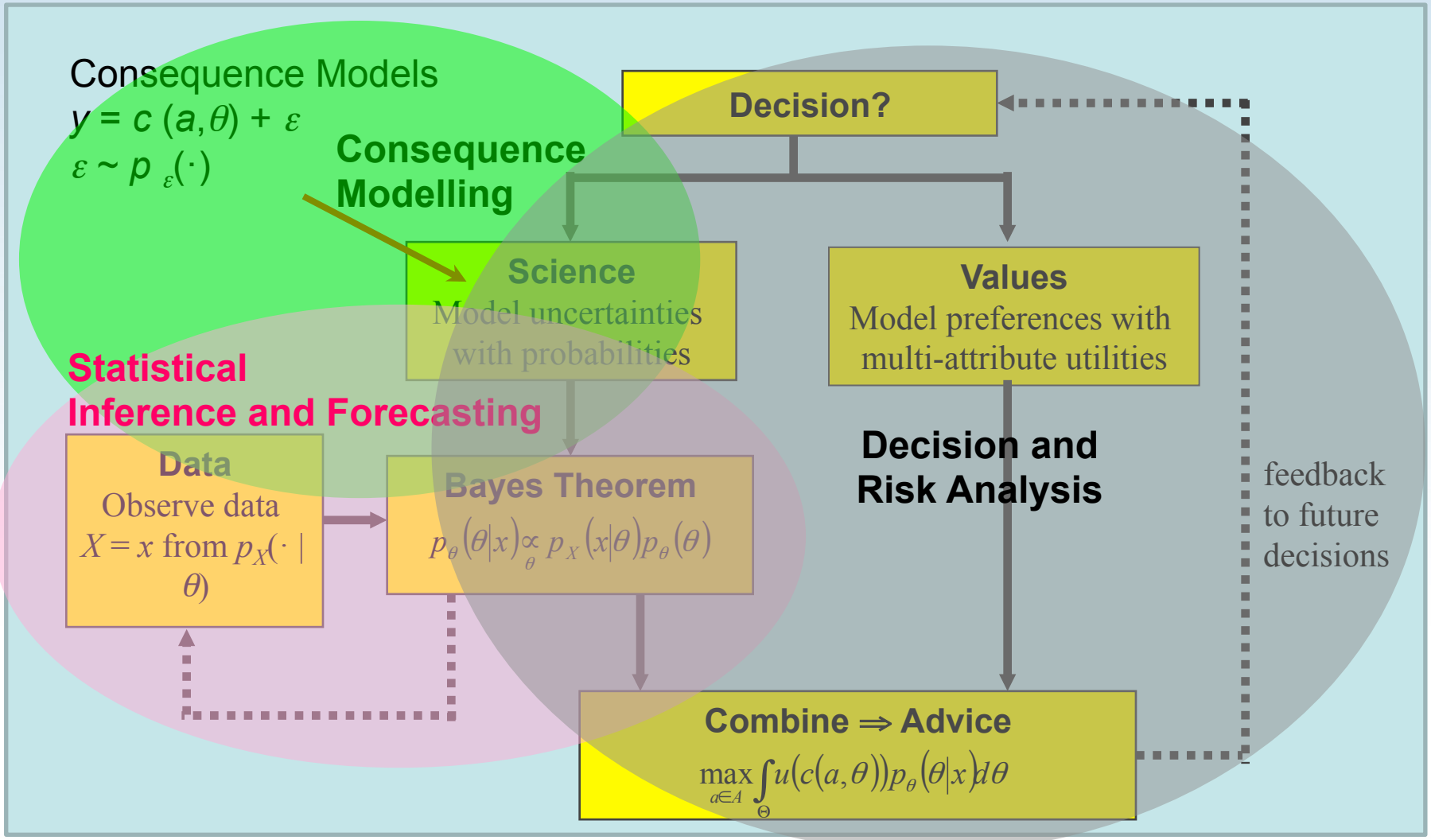
Societal Decisions



The Bayesian DA Paradigm



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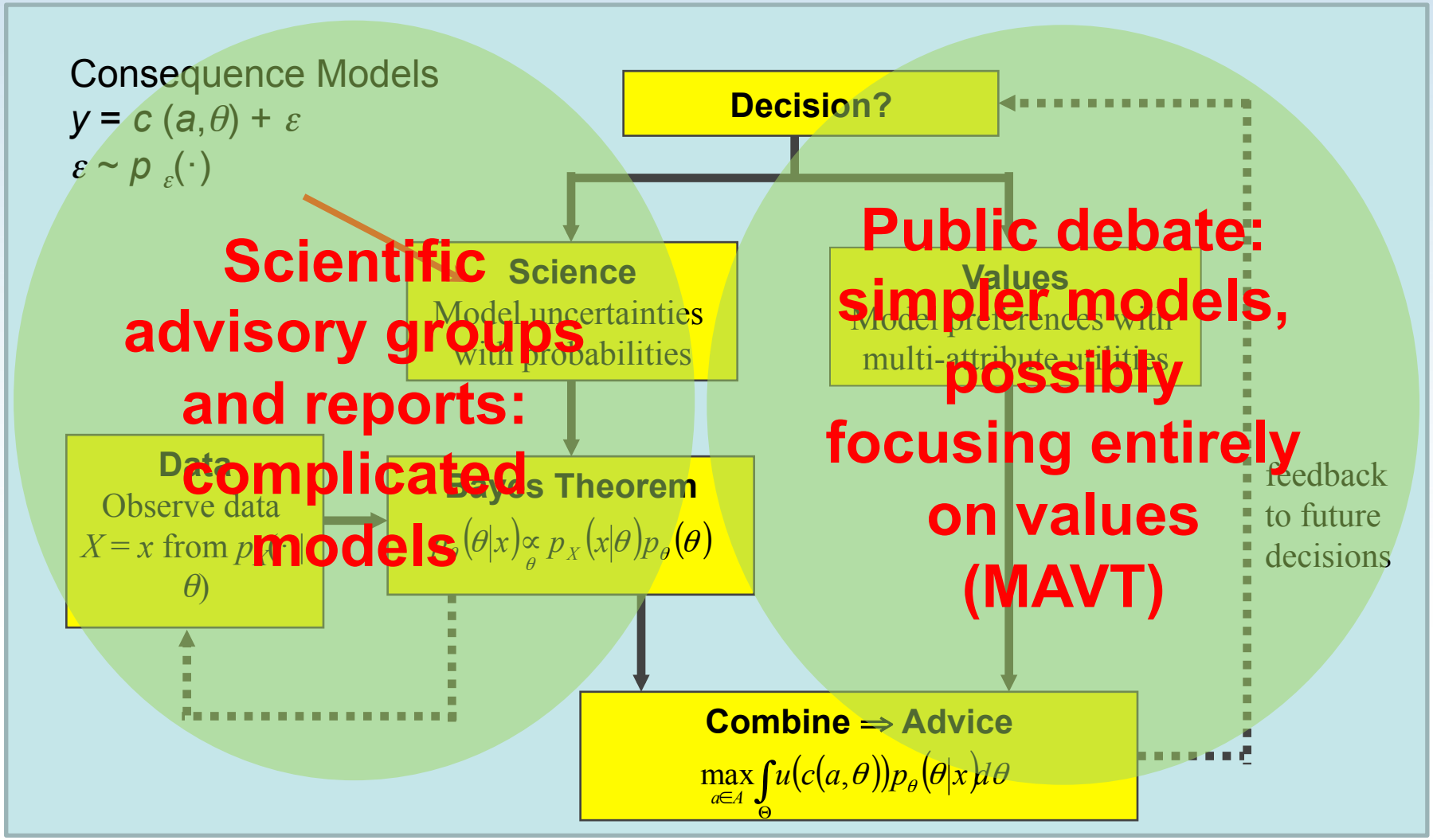

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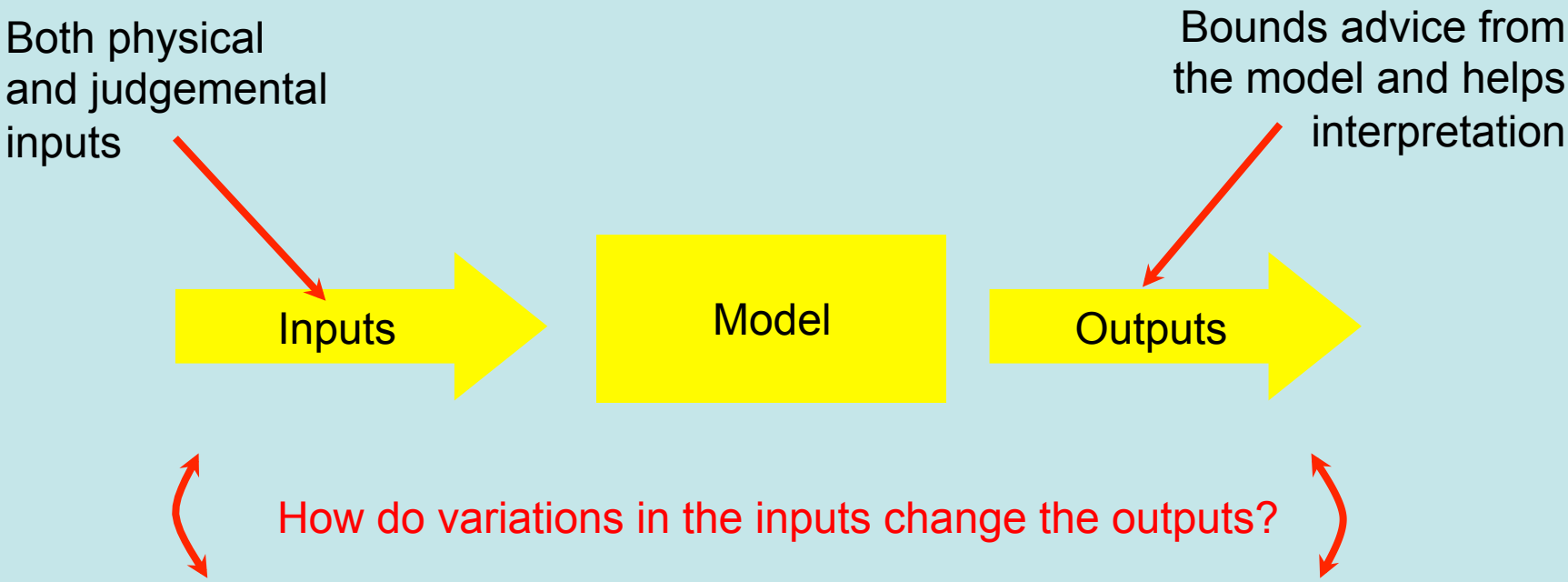


- Guides the making of inferences, forecasts and decisions;
- Helps explore group differences and builds consensus;
- Generally builds understanding.

The Bayesian DA Paradigm

The ‘textbook view’ of Decision Analysis suggests that to balance with uncertainty and values:

- Represent the uncertainties by a probabilities
- Represent values by utilities
- Analyse via Bayes Theorem and Expected Utility
- Conduct a sensitivity analysis

Problem: It doesn’t always work!

- Sometimes we cannot define the probability distributions
- Sometimes we cannot define our values
- Sometimes we do not know what is ‘out there’
- Sometimes we do not know what is ‘in us’

Deep or Knightian Uncertainty

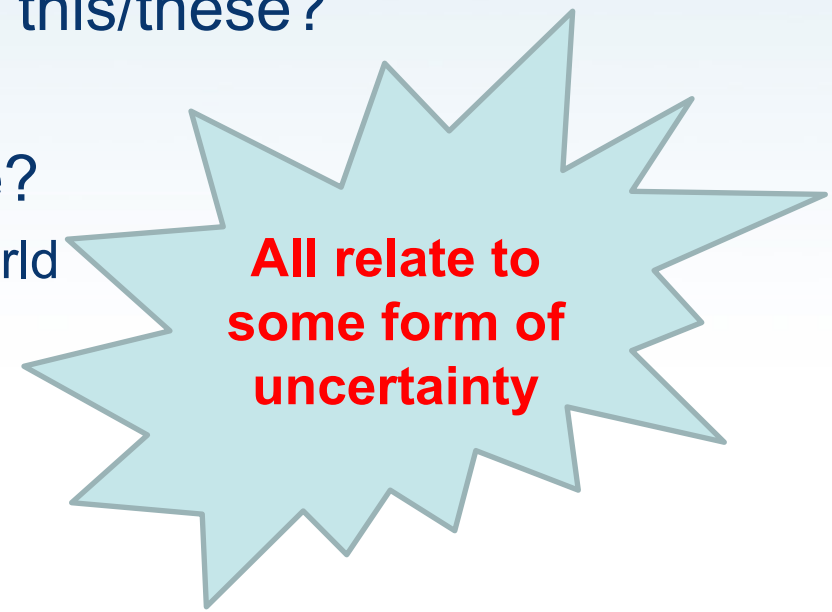
- What happens when the uncertainties in some events/ quantities are ***so deep*** that while any expert might express his or her uncertainties as probabilities, the range of these probabilities over a group of experts is effective 0-1?
- Sensitivity analysis will give almost anything as possible.
- Some uncertainties are ***too great*** to build a ***'useful' model***.
- Knight (1921) distinguished:
  - ***Risk*** contexts: probabilities known and available
  - ***Uncertainty*** contexts: probabilities unknown or unavailable

Disagreement on Values

- The DA paradigm is individualistic
  - Arrow's Impossibility Theorem
  - Even when group utilities might exist, there is a need for dubious interpersonal comparisons
- So DA proceeds by using some sort of group mean analysis and then using sensitivity analysis to articulate discussion
- But what happens when group members differ so much that there is no sensible group mean?
  - Stakeholder differences in societal problems

Key questions in 'messy' decision making

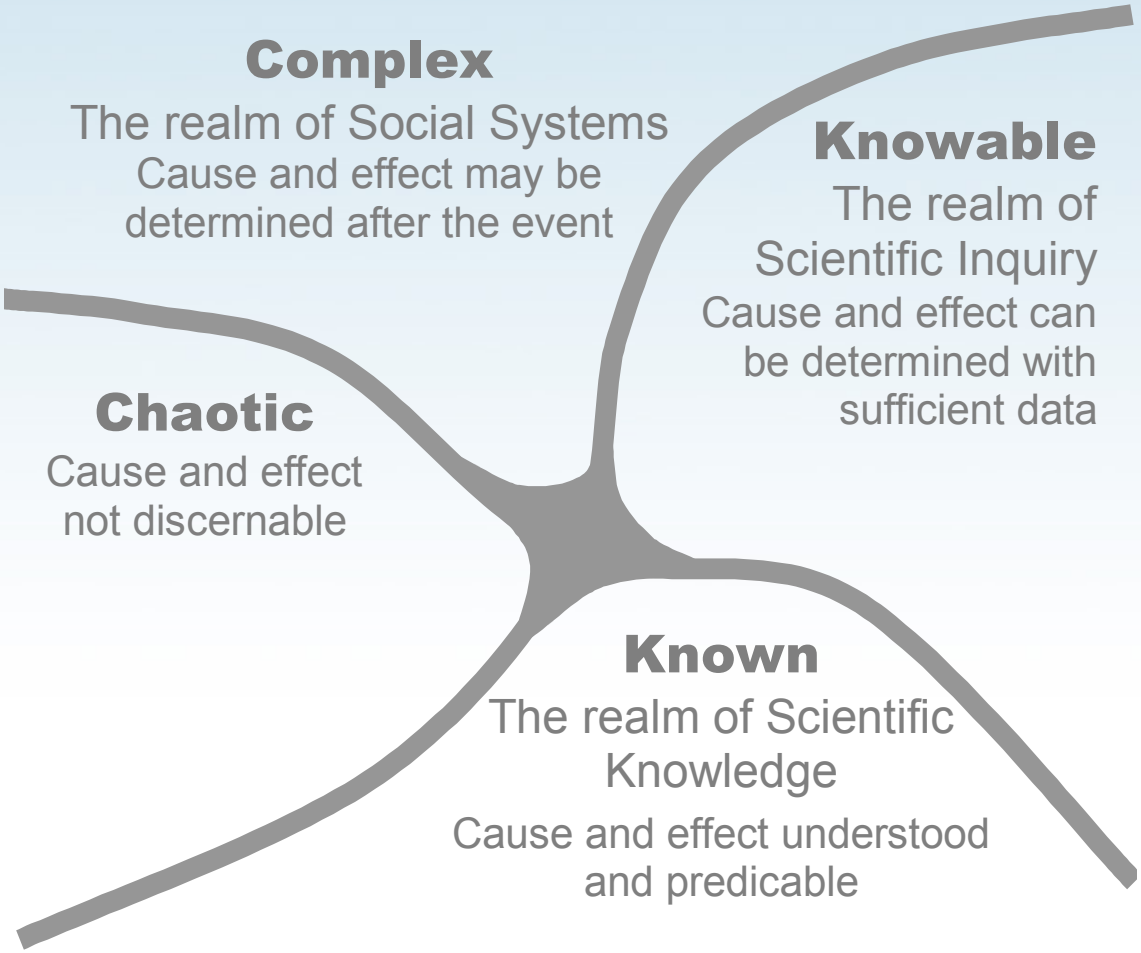
- What are our concerns?
  - (lack of) understanding of world *and ourselves*
- What are we trying to achieve?
  - values & objectives
- What might we do to achieve this/these?
  - actions/strategies
- What might happen out there?
  - uncertainties about external world
- What might result?
  - consequences
- How much it matter if it does
  - Impact in terms of our values



Cynefin: a Welsh habitat

Cynefin:

- physical environment
- cultural environment
- social environment
- historical environment
- …..



D. Snowden (2002). "Complex acts of knowing - paradox and descriptive self-awareness." *Journal of Knowledge Management* **6** pp. 100-11.

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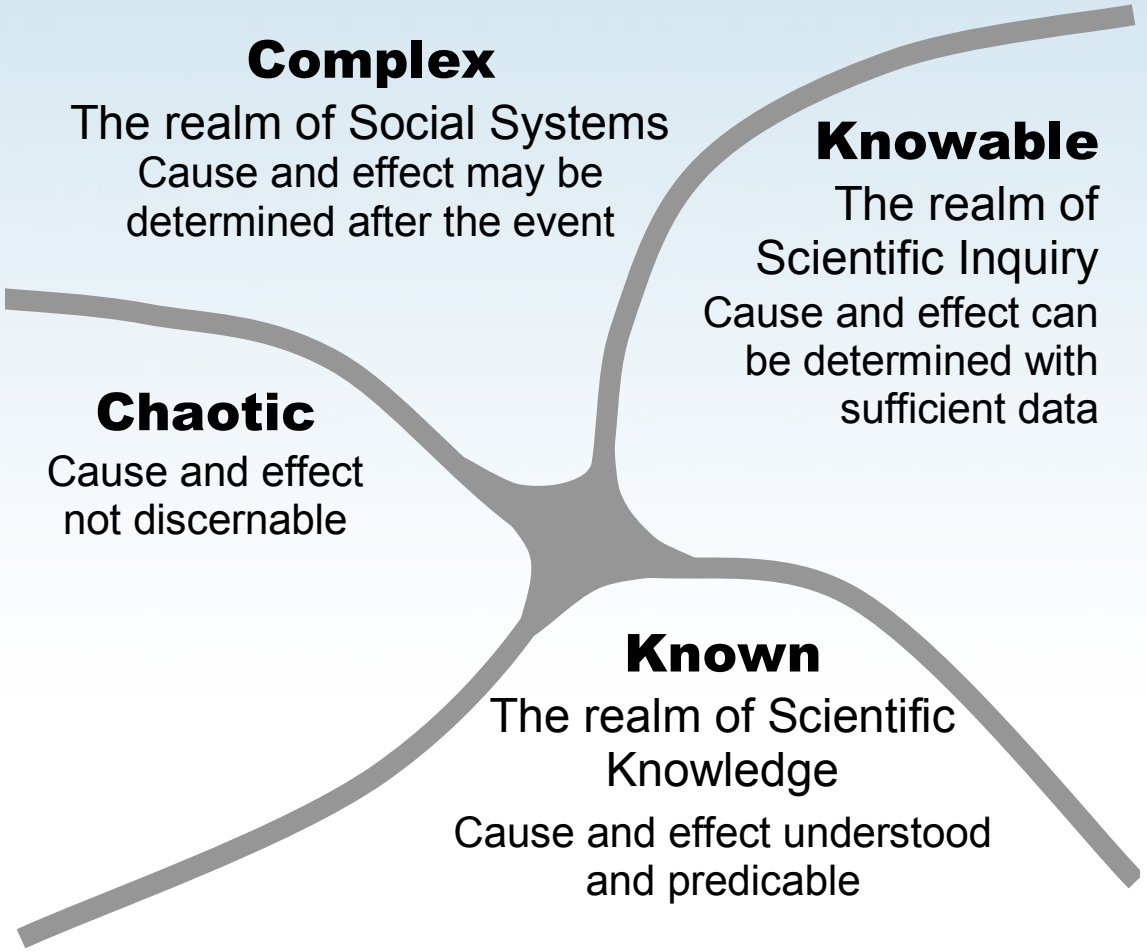

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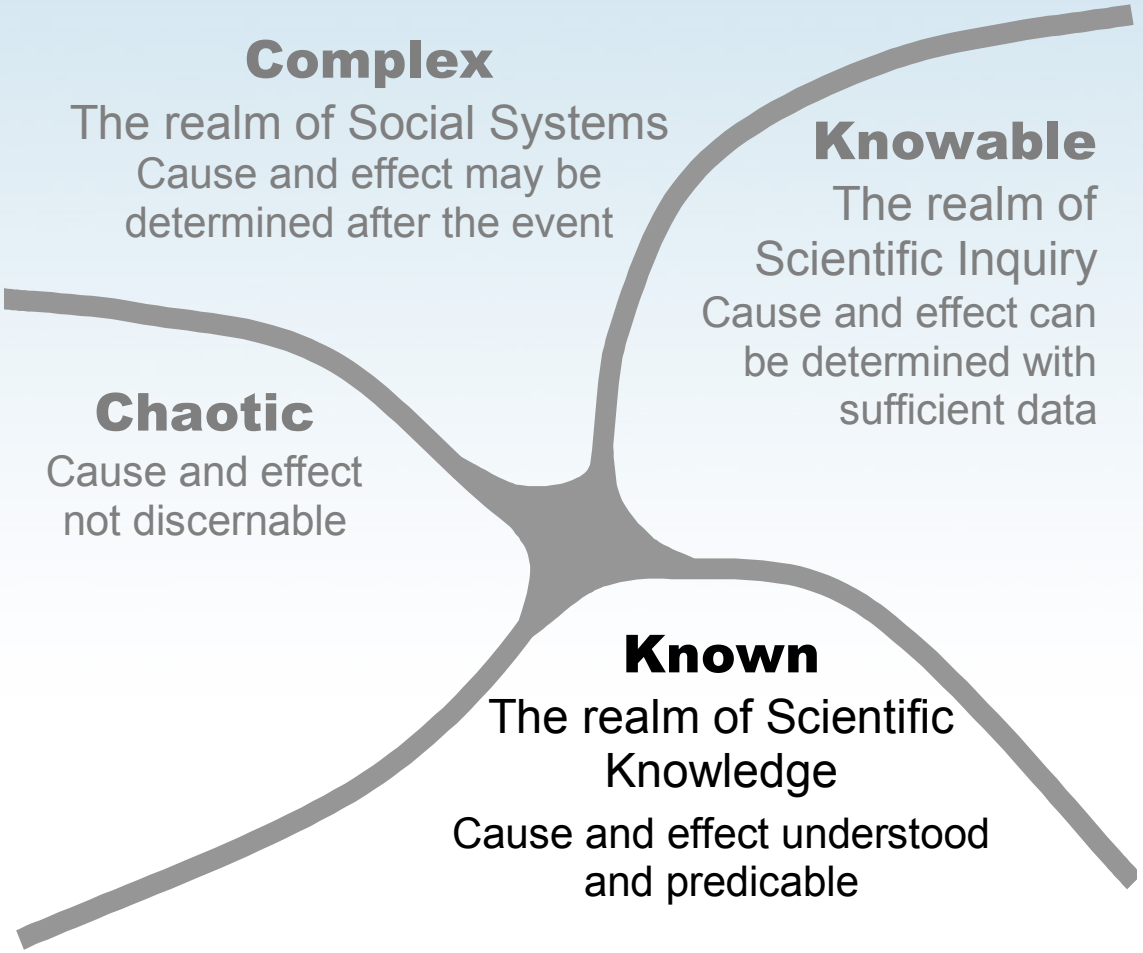

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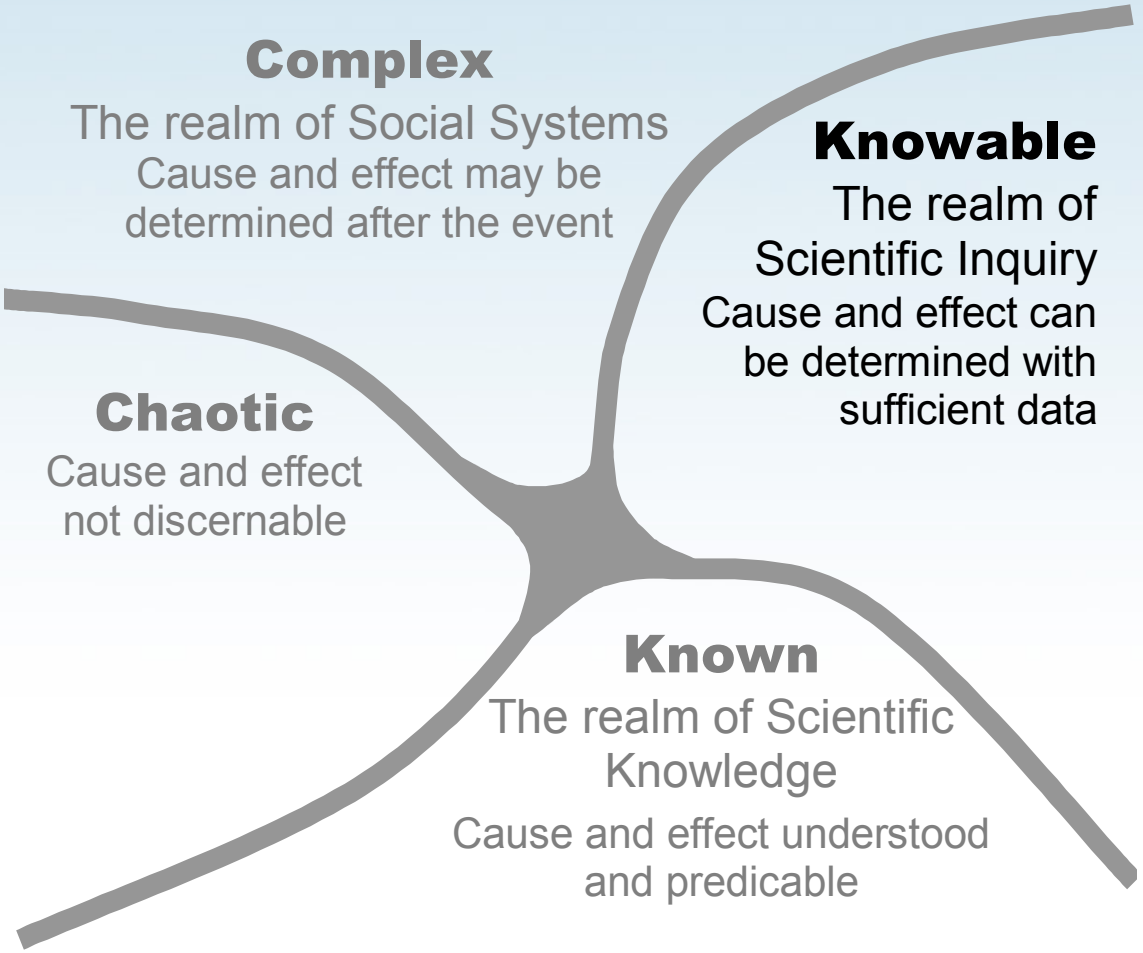

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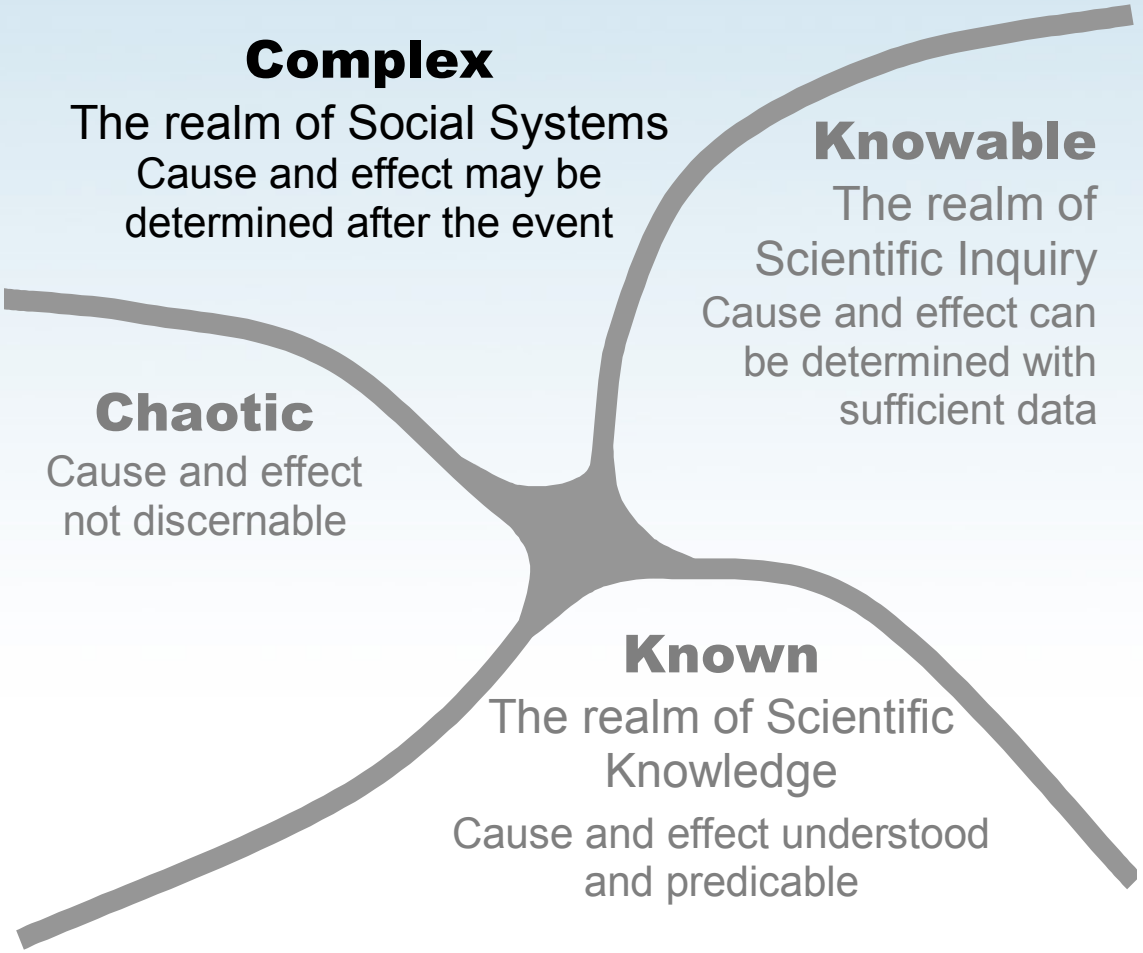

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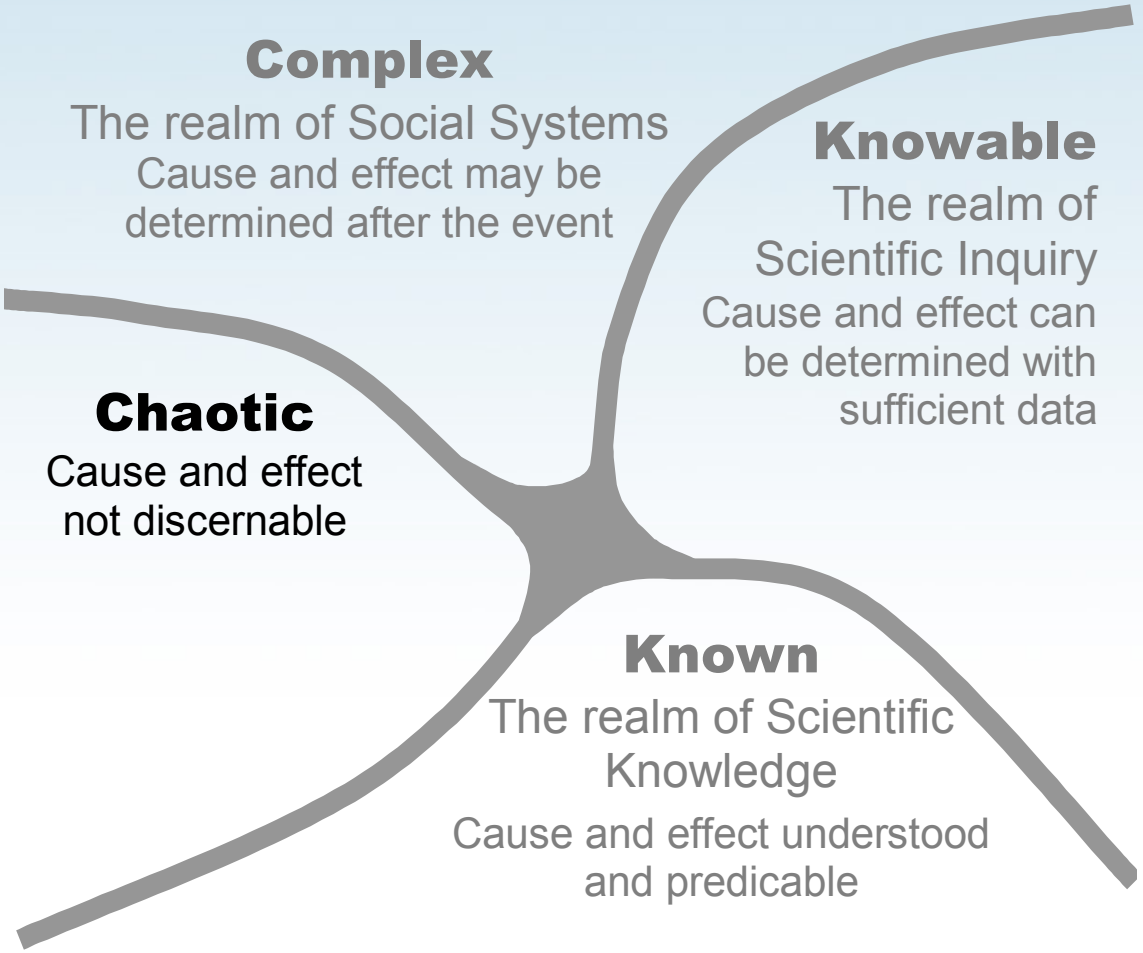

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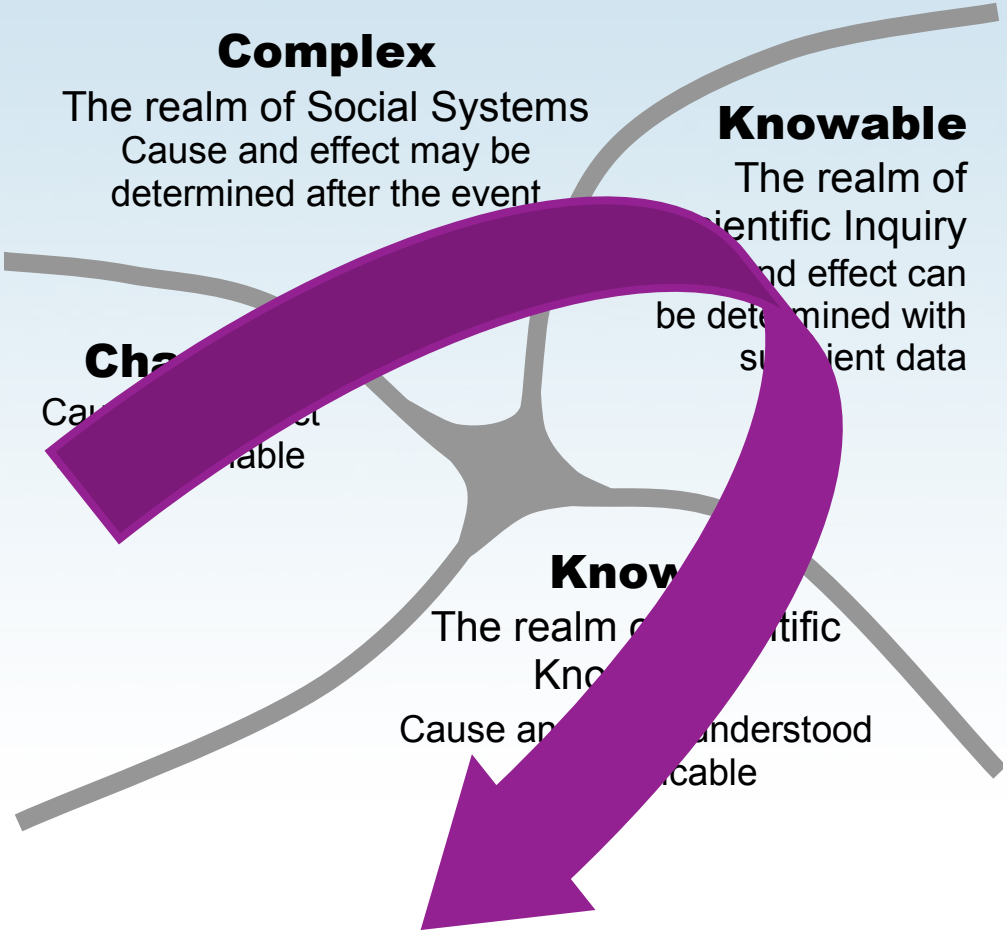
Cynefin: learning, repeatability



Repeatability and increasing familiarity

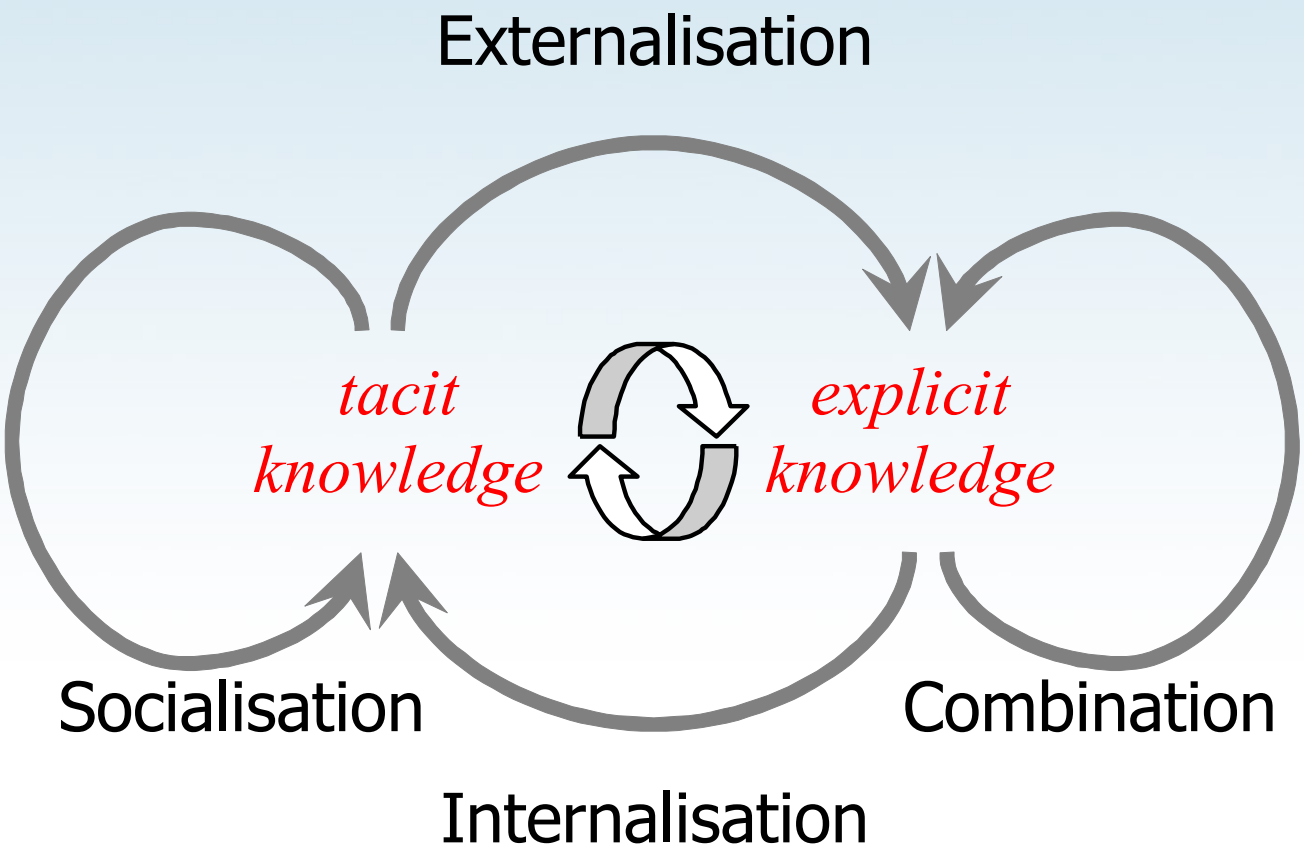
Knowledge Management

Knowledge and Uncertainty are opposites:

Uncertainty  Knowledge

So the literature of knowledge management might have something to tell us …

Knowledge Management and Nonaka's SECI



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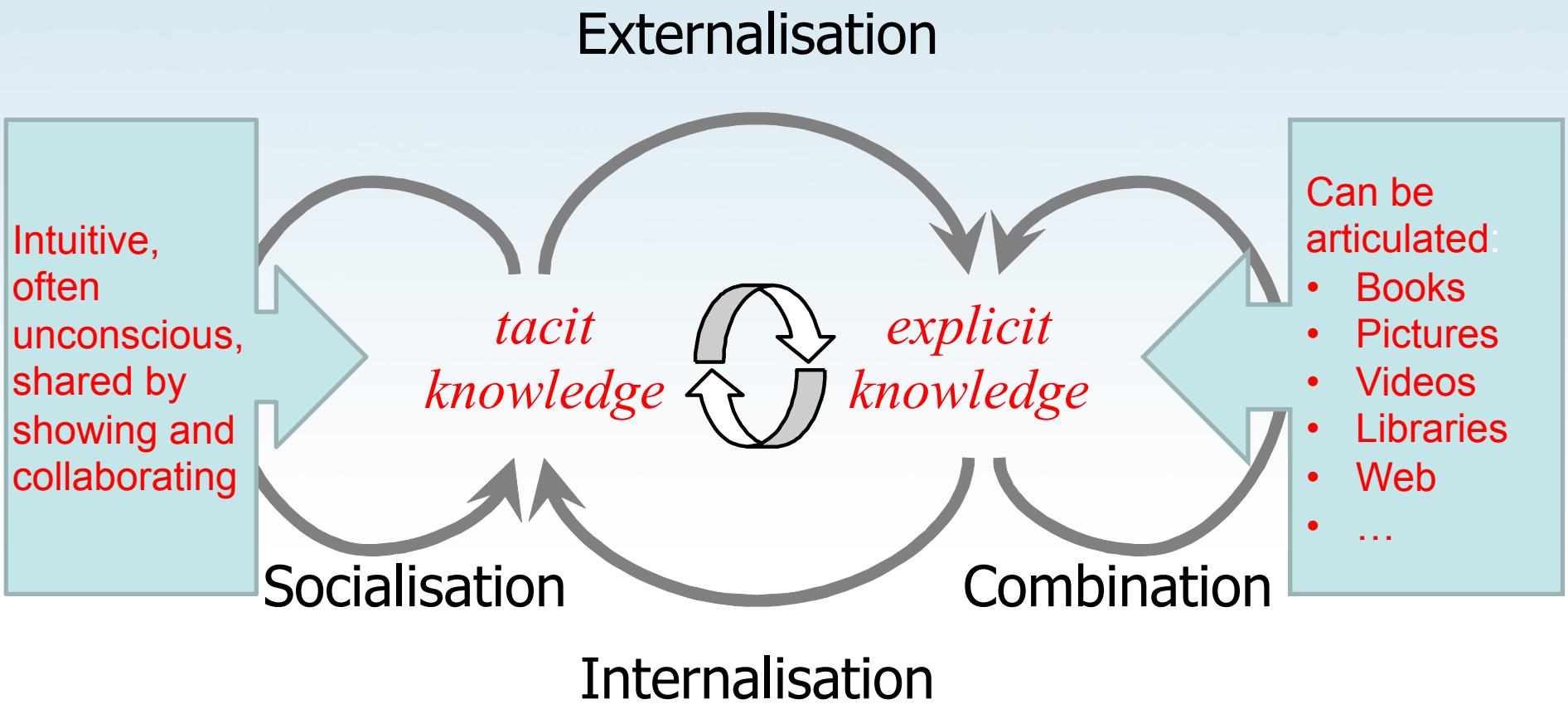
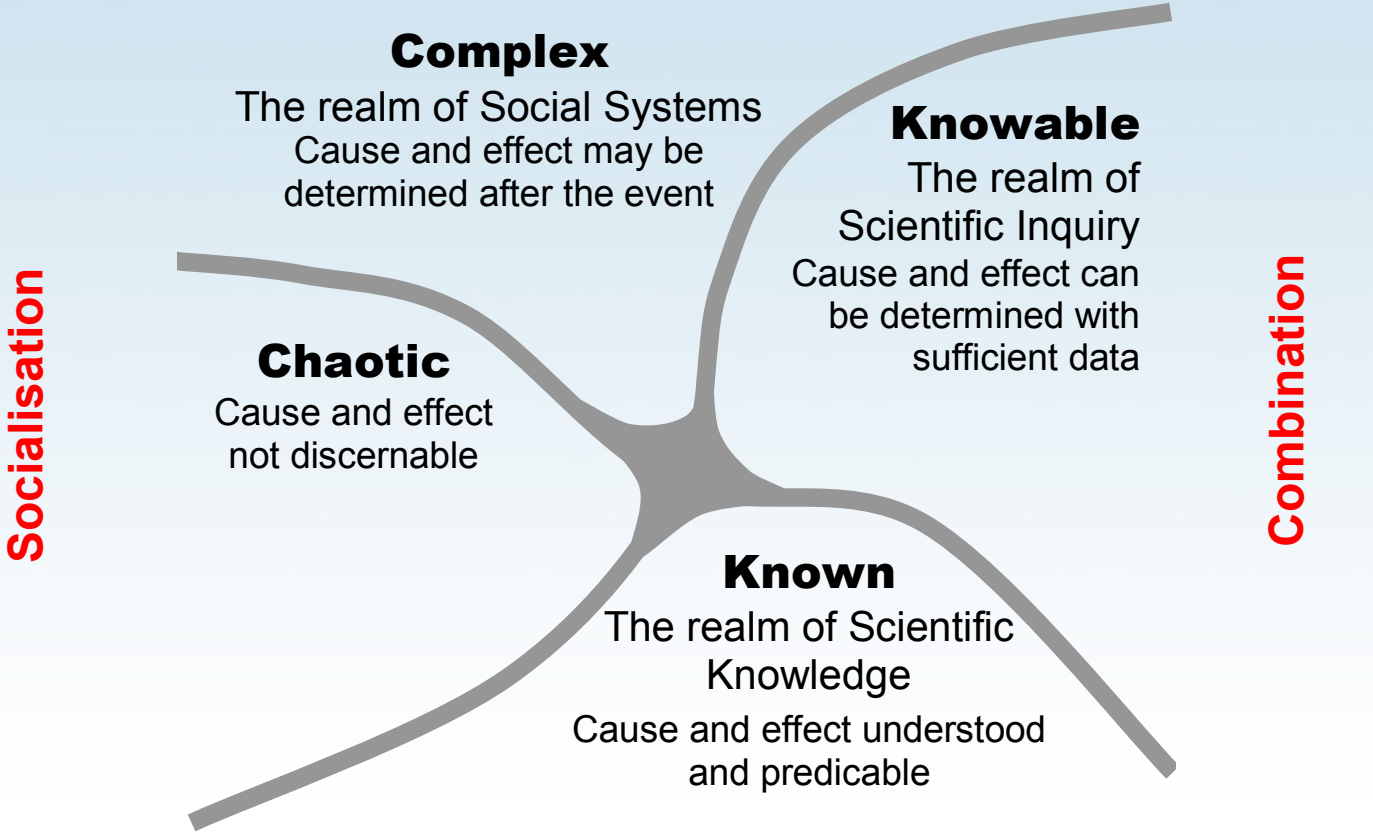


Cynefin and Knowledge Management



Explicit Knowledge
Formal, explicit analysis

Tacit Knowledge
Sense-making & collaboration tools

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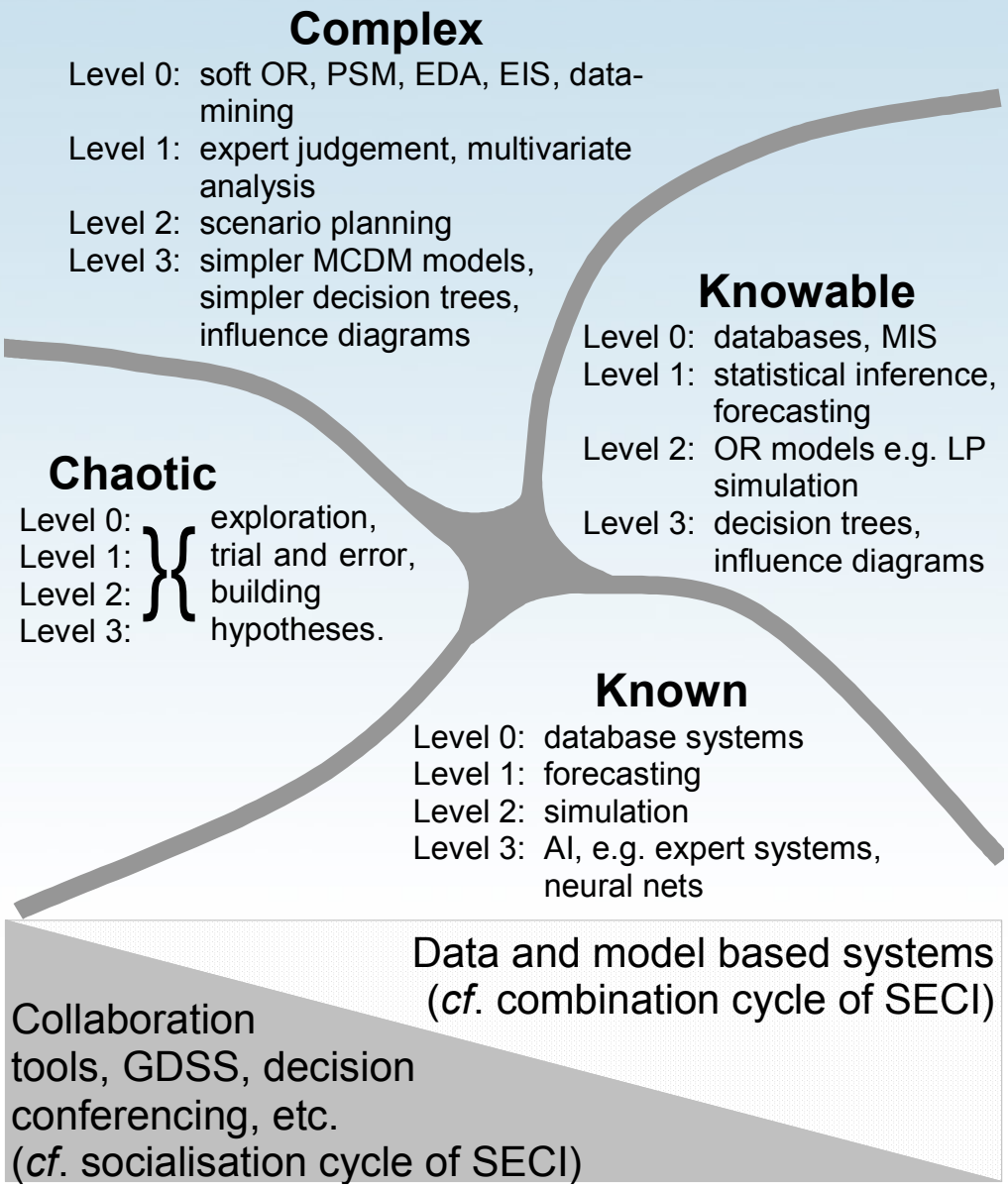
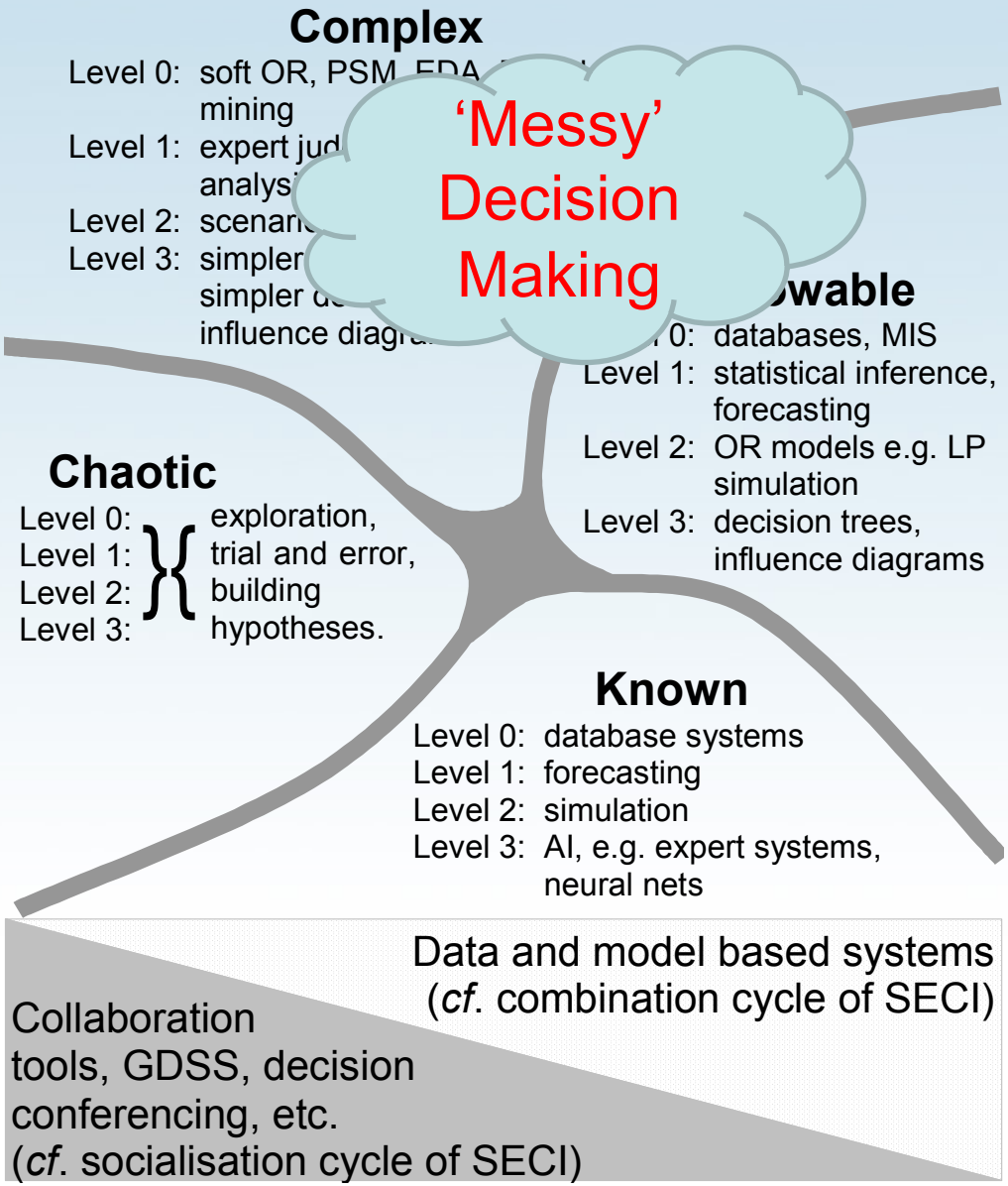


Level 0: Acquisition, checking and presentation of data, directly or with minimal analysis, to DMs

Level 1: Analysis and forecasting of the current and future environment.

Level 2: Simulation and analysis of the consequences of potential strategies; determination of their feasibility and quantification of their benefits and disadvantages.

Level 3: Evaluation and ranking of alternative strategies in the face of uncertainty by balancing their respective benefits and disadvantages.



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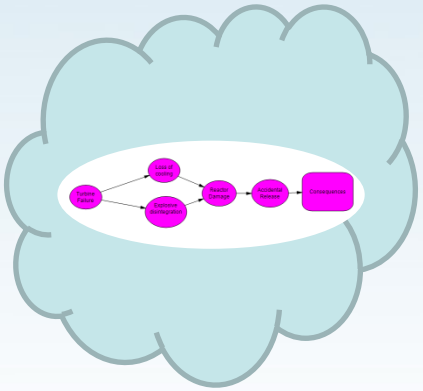
Scenario-Focused Decision Analysis

An approach to deep uncertainty and conflicting stakeholder values

- Use scenarios to ‘fix’ deep uncertainties at *interesting* values
  - No attempt to span or partition the future
- Also create scenarios which capture specific value/cultural perspectives.
  - Hierarchist, Individualist, Egalitarian, Fatalist (Douglas)
- *Within* each scenario, build an appropriate quantitative model/small world
  - Possibly a different model in each scenario.

Example: Threatened Nuclear Accident

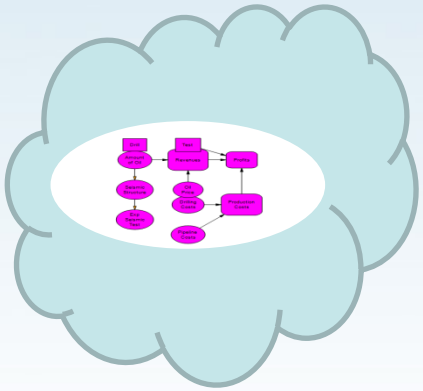
Scenario 1



No Release

Engineering solution avoids accident

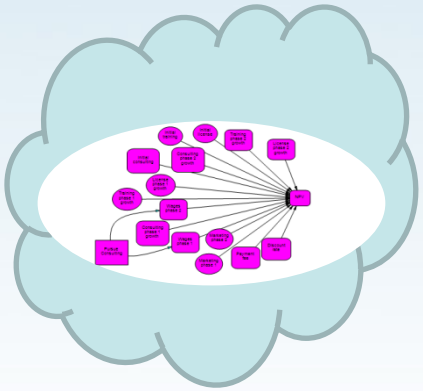
Scenario 2



Small Gas Release

Some release of radioactive gases.

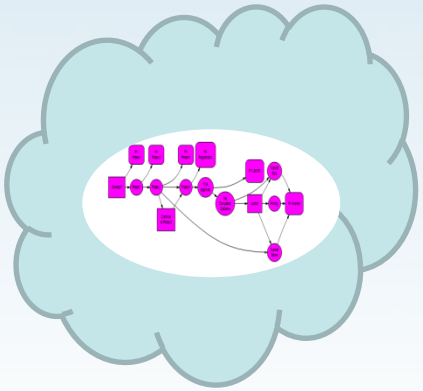
Scenario 3



Gas and some Particulate Release

I_{131} and other radionuclides released

Scenario 4



Major Release

Large gaseous and particulate radionuclides release.

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Other Examples

- Energy futures (Kowalski et al, 2009)
  - Includes participatory processes
- Natural resource management (Mendoza & Martins, 2006)
- (i) broker strategy & (ii) warehouse development (Montibeller et al, 2006)
- Emergency planning (Comes et al, 2010)
- Infrastructure policy (Schroeder & Lambert, 2011)

All are experimental between research and production decision analysis ⇒ much more to be done.

There are many problems …

- How might we accumulate results of analysis across scenarios?
  - We might not!
    - Present the within scenario analyses to inform discussions, but leave the synthesis to judgement and the political process.
  - If we do accumulate …
    - What do between scenario weights *mean*?
      - Not simple probabilities nor preference weights, maybe *importance*
      - Stewart, French & Rios Omega (2013)
    - How do we assess them?
- Can the DMs learn from such analyses?
  - How do we present the results?
- Can the DMs provide the necessary judgements to build the 'what-if' models?
  - Requires counterfactual thinking
- There are theoretical issues relating to the Bayesian model.

Thank you and questions

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