



# The ability of models to predict the effects of policy decisions

## M2D Conference on Decision Making Under Uncertainty

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[ES/N012550/1](#)





## CECAN Aims and Summary

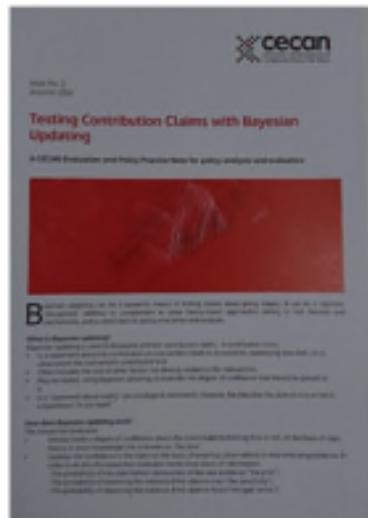
### Ex-post policy evaluation

- To integrate complexity into policy evaluation and to enable more effective policy-making
- To catalyse a step-change in policy evaluation for complexity and Nexus issues
- Started 1st March, 2016
- Initial funding (£2.45 million) for 3 years from ESRC, NERC, Defra, BEIS, EA, FSA



# Practitioner accessible outputs

## Policy and Practice Notes





# CECAN Partners

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UNIVERSITY



 Durham  
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EA EUROPEAN ACADEMY  
OF TECHNOLOGY AND INNOVATION ASSESSMENT

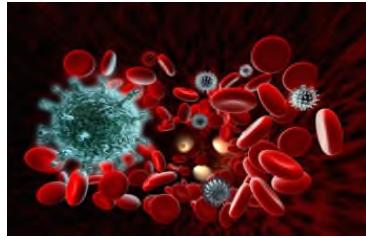
UNIVERSITY *of York*

  
ARIZONA STATE  
UNIVERSITY

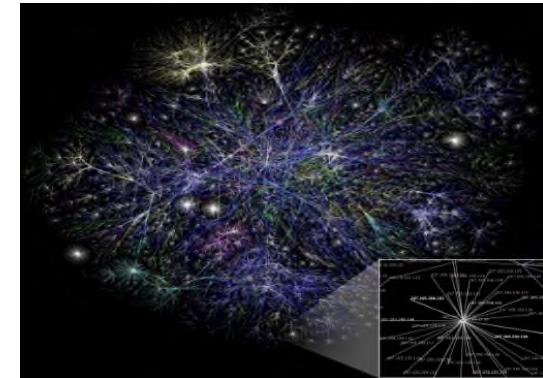
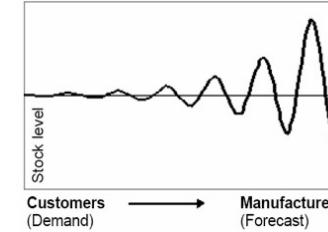
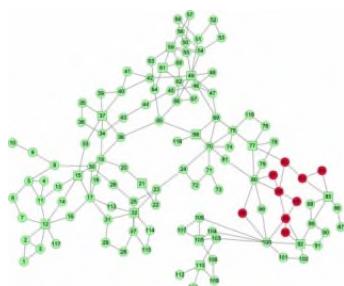
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# Complexity



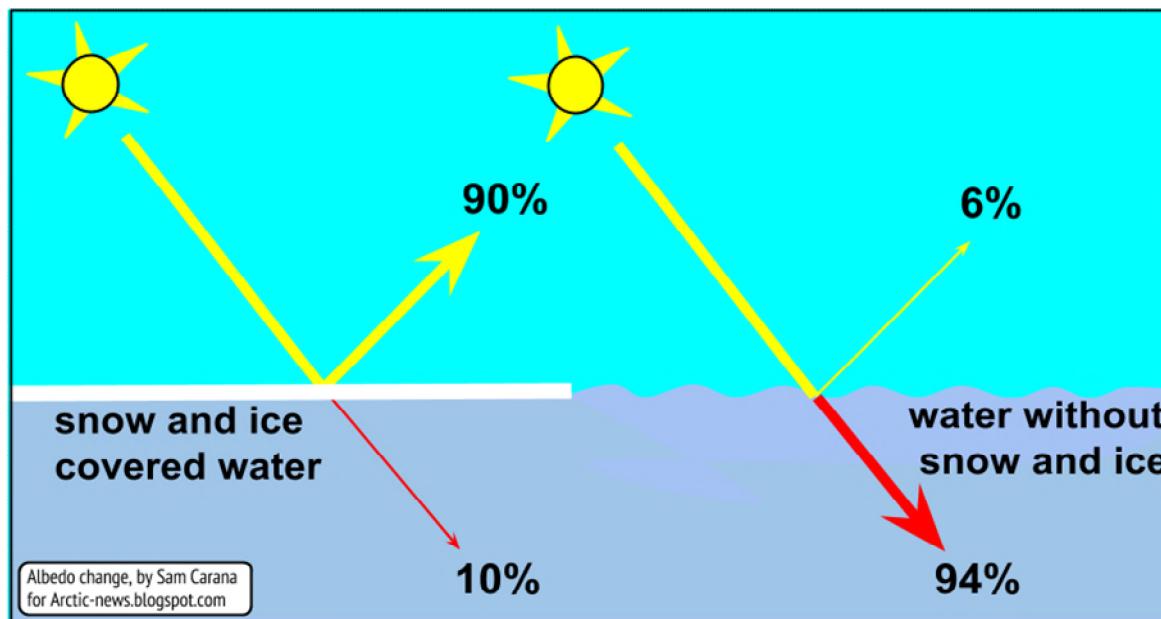
- Interconnectedness
- Heterogeneity
- Feedback and non-linearity
- Emergent order, structural attractors
- Path dependency/initial conditions
- Distributed control/self organization
- Co-evolutionary adaptation, learning





## Feedback

- Positive feedback
  - The cases of bull and bear markets; albedo and climate change
- Negative feedback
  - The cases of the thermostat; budgets



## Non-linearity

- Non-linearity defines the concept of outputs being disproportional to inputs: an example is the effect of economies of scale
- In complex systems, there are multiple feedbacks between inter-dependent systems, which become entwined creating non-linearities, emergent properties and transitions to new structural attractors: flooding through inability of built and eco-systems to contain water





## CECAN EX-POST policy evaluation

- Multiple methods available (better than Randomized Control Trials) which can evaluate the effectiveness of policy
- Usually computational methods involving models which can represent how the system responded to a policy intervention
  - They can identify differences from ex-ante expectation
  - The arrival of unexpected factors that influenced the system, e.g. trade tariff variations
  - They can test counterfactuals – would the outcomes have been any different without the intervention?
- With ex-post knowledge
  - feedback can be represented
  - non-linearities can be observed in the consequences of virtual stakeholder behaviour
  - And even abstract or parsimonious models can accurately describe the effects of decisions



## Predicting non-linearities

- EU-Innovate – European Commission project [FP7-SSH - 613194](#)
- Domestic Innovation
- Heat demand depends on a number of
  - U values of building components (windows, doors, etc.)
  - difference in desired indoor and actual outdoor temperatures (over some time period)
  - number of occupants and their behaviours
  - number of rooms/space
  - number of devices (and waste heat)
  - etc.
- So when a home is insulated the actual reduction in heat is a result of the feedbacks between the above which has a consequent non-linear effect on heat demand



# Public policy evaluation for complex system

- The uncertain effects of feedback and non-linearity **in the real world** are major challenges for users relying on models to inform their decisions particularly regarding public policy





## Challenges for public policy makers relying on models

- Models are invariably sectorally organized, informing the industry or sector for which the model has been commissioned
  - However consumers attracted by the policy instrument do not recognize such artificial sectoral boundaries
- Time lapses between policy announcement and implementation allows stakeholders to prepare strategies (to not be worse off generally)
- The policy intention is re-interpreted into a policy instrument and may target particular parts of the population
- The execution of the instrument may vary from the instrument, e.g. cases of discrimination
- Monitoring/surveillance/remedial action may vary in strictness
- The timing of the evaluation may create different results



## Bovine Tb – case study

- Time series data of cattle infection rates by location
- Also for other animals, potential carriers of bTB
- Payment data to farmers (which is less than the revenue of the animal)
- Rolling 3 month prioritized testing
- Delay in test results meaning animals can infect others meanwhile
- Delay in sending to slaughter and risk of contamination en route
- Correlation of high bTB and financial crisis 2008





# Models for the past, the present and the future

- **EX-POST** (some do this)
  - Retrospective evaluation, calibration, etc.  
E.g. Windrum, Paul, Fagiolo, Giorgio and Moneta, Alessio (2007). 'Empirical Validation of Agent-Based Models: Alternatives and Prospects'. *Journal of Artificial Societies and Social Simulation* 10(2)8 <<http://jasss.soc.surrey.ac.uk/10/2/8.html>>
- **REAL-TIME** (digital twins)
  - High speed computing, data prevalence/IoT, Machine Learning
- **EX-ANTE** (most models do this)
  - Probabilistic evaluation of a system's future 'performance' by considering
    - Scenarios (e.g. population growth vs normative futures)
    - Intervention effects
  - Purpose: identify variability of a limited range of outcomes by selecting alternative scenarios in which to examine potential policy interventions

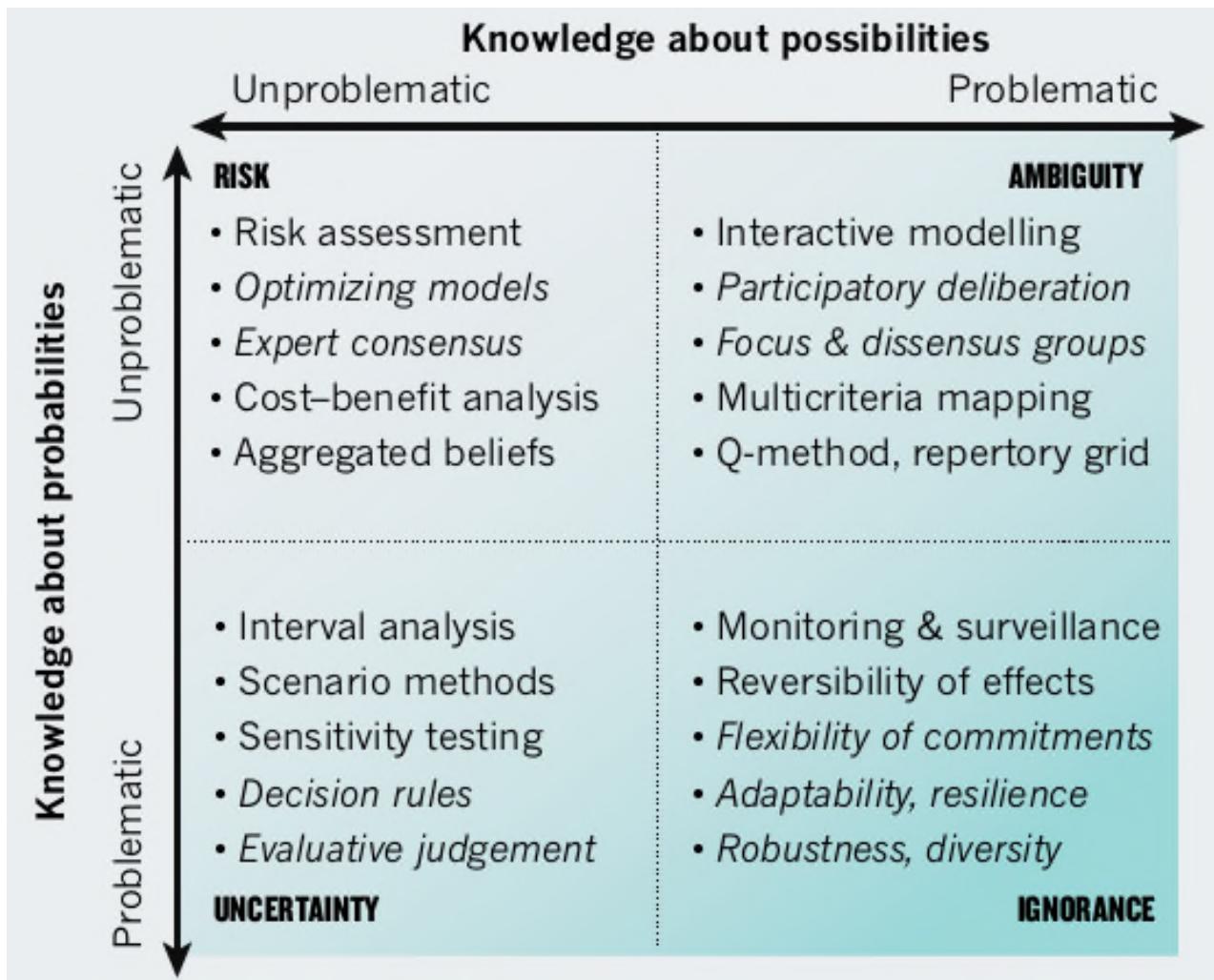


## Appropriate models for *ex-ante* policy assessment?

- Models **can** simulate exceptionally complex (co-evolving) systems
  - Statistical and CGE limitations
  - Agent based or hybrid ABM and network models can represent (simplify) behaviours (rules) of stakeholders, feedback and non-linearity in response to public policy decisions and instruments
  - *Participatory* methods are needed to identify and access the breadth (range) of stakeholder responses to future policy interventions, noting that stakeholders are heterogeneous and exist at multiple scales
- Past behaviours may not be relied upon for extant decision-making (more uncertainty!): need for machine learning



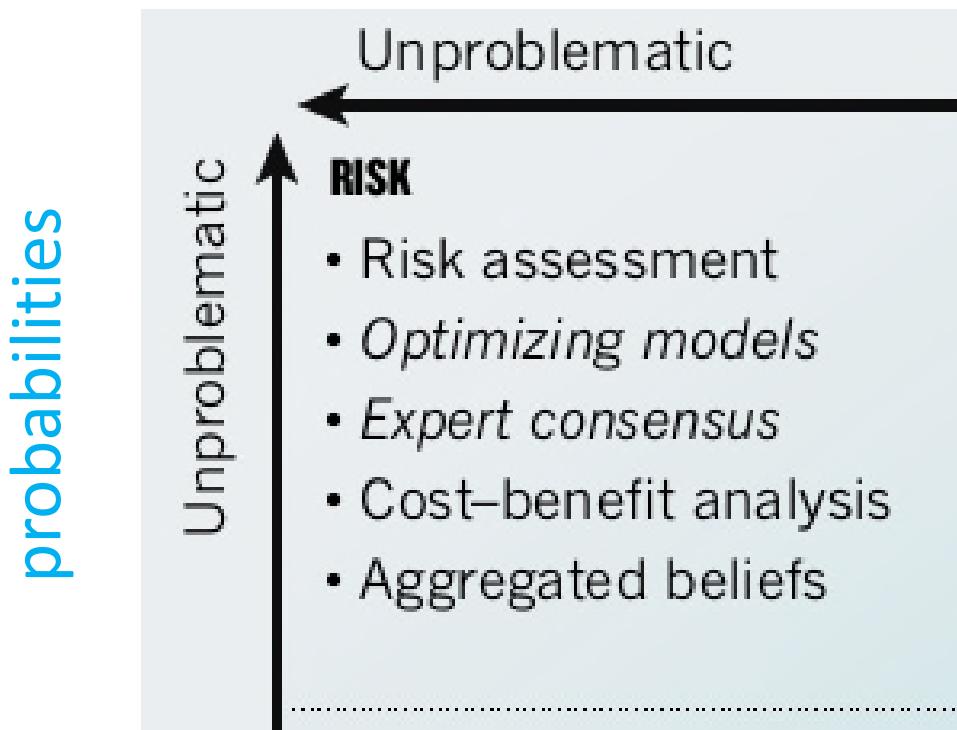
# Risk, Uncertainty, Ambiguity and Ignorance





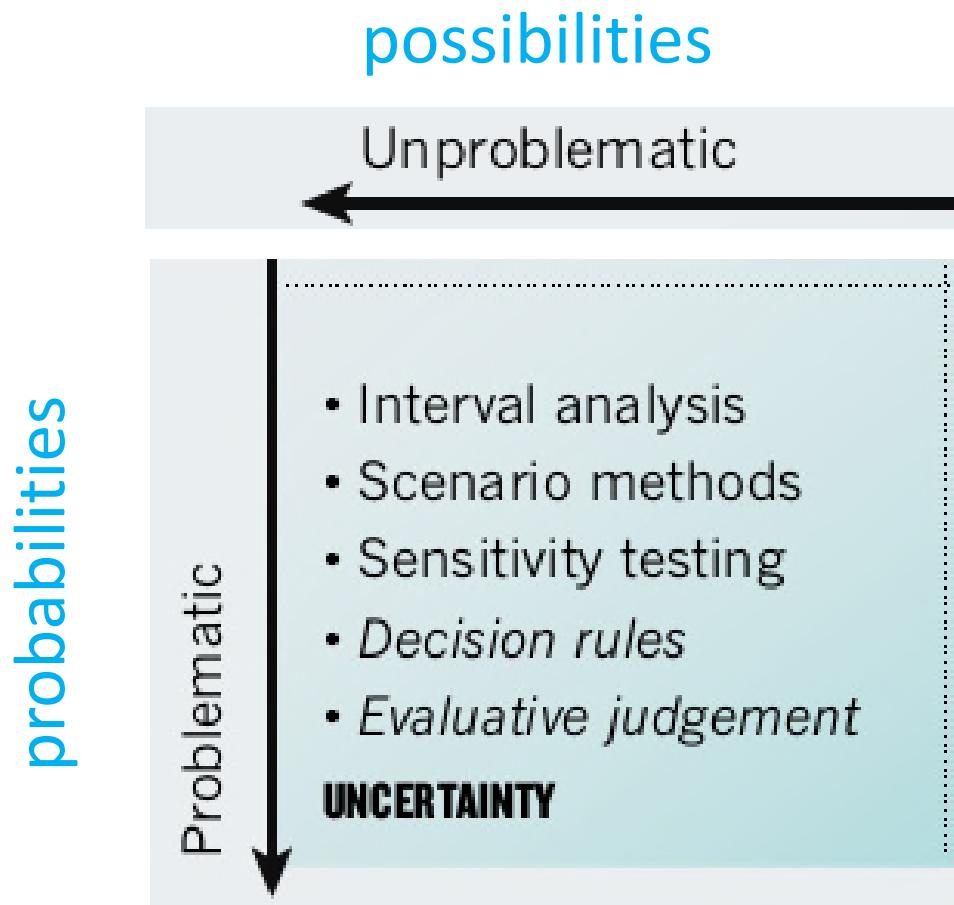
## Statistical uncertainty = risk!

possibilities





# Uncertainty – when probabilities are unknown





## Question of risk AND uncertainty

**Life is an experiment**

- Every situation is unique, but of course patterns re-appear
- Question should be **“How responsive does a system need to be, given the changing risk *and* uncertainty in the system?”**
- Need for
  - adaptive, flexible systems
  - monitoring/detection (e.g. via IoT)
  - periodic or even continuous re-evaluation of risk and uncertainty
  - responsive, dynamic governance



## Methods

- **Deduction – physical, chemical**
  - positivist terminology used in empirical conceptions: universal laws, evidence, objectivity, truth, actuality, reason, fact, quantitative: validity by disassociating from data collection processes
  - Winter, G, *The Qualitative Report*, Volume 4, 2000 (<http://www.nova.edu/ssss/QR/QR4-3/winter.html>)
- **Induction – social, technical**
  - Plurality, negotiation of 'truths' through a series of subjective accounts, qualitative researchers have come to embrace their involvement and role within the research (sic)
- **Abduction and mixed methods**
  - abduction: emerging theoretical ideas are refined alongside increasingly systematic empirical analysis (Mantere and Ketokivi, 2013)
  - Using methods in some combination to understand a system or phenomenon, which requires both quantitative *and* qualitative data
  - Varga, L (2017) Mixed Methods Research: A method for complex systems; Edward Elgar Handbook of Research Methods in Complexity Science (Mitleton-Kelly, E. ed): ISBN 978 1 78536 441 9



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Questions?



EPSRC grant [ES/N012550/1](https://www.esrc.ukri.org/research/programmes/strategic-programmes/nexus-of-innovation/cecan-centre-evaluation-complexity-across-nexus/)

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