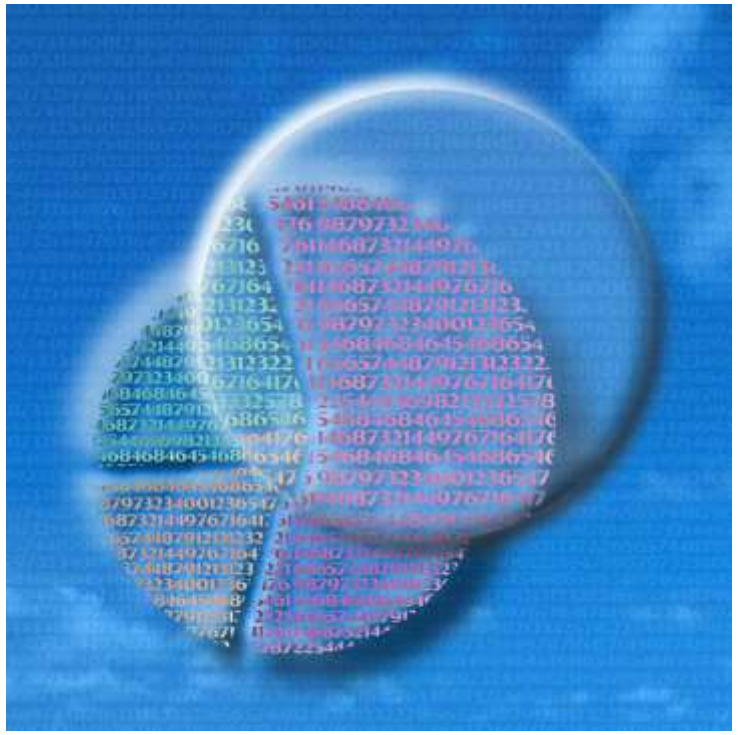


On modelling

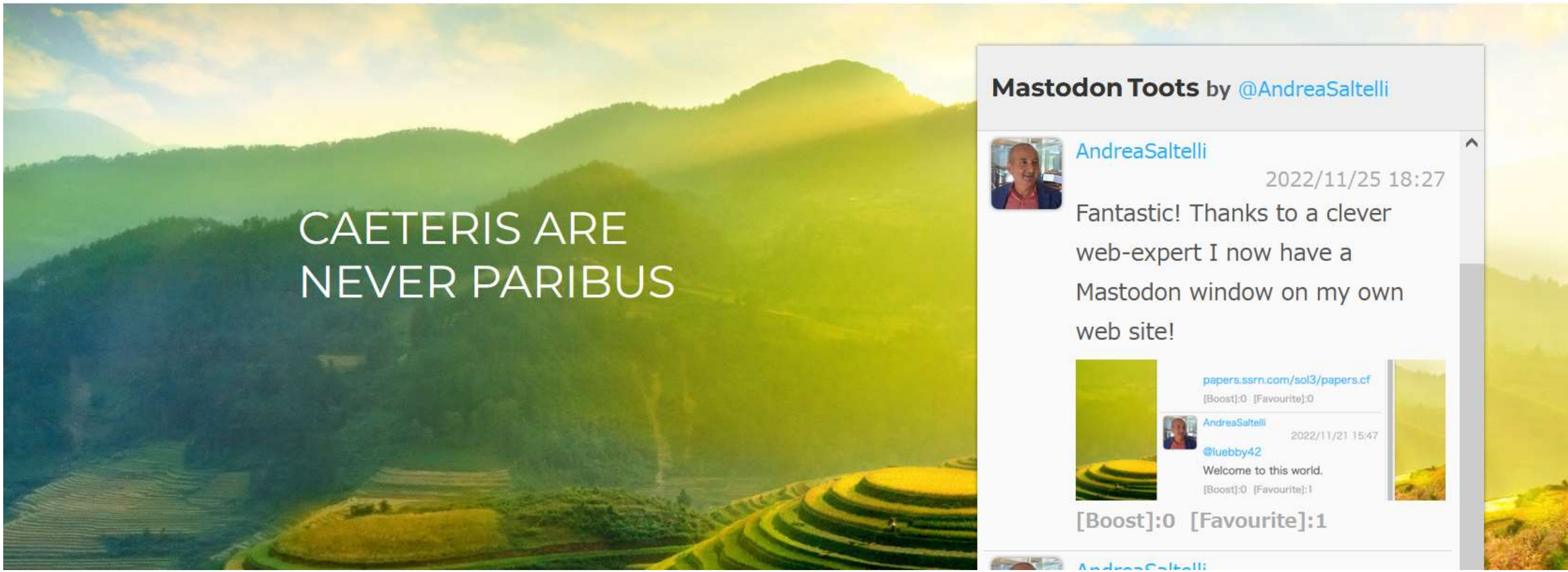
Andrea Saltelli,
November 28 2022

JRC course on sensitivity analysis,
Brussels, November 28-29

First part – 28 Nov
9:30- 10.00 Round table with participants
10:00 -10:30 Welcome, introduction, the use of evidence in the Better Regulation context, models, models in impact assessment (Paul)
10:30 – 11:10 Models, uncertainty and model quality assurance (**Andrea, 40m**)
11:10-11:45 Uncertainty analysis & Sensitivity analysis concept and brief history, Basics of statistics, Monte Carlo method (Stefano)
11.45-12 (break 15 mins)
12:00-12:30 Uncertainty and sensitivity analysis in impact assessment (**Andrea 30m**: stress on OAT vs GSA)
12:30-13:15 Steps of a sensitivity analysis I part (Rossana: OAT example/scatterplot/introduction to SI)
Closure All
Second part – 29 Nov am
9:15-9:45 Steps of a sensitivity analysis II part: variance-based and Sobol' method (Stefano)
9:45-10:20 Use of Siml@b tool for global sensitivity analysis (Rossana)
10:20-10:50 Examples of sensitivity analysis results (**Andrea 30m**)
10:50-11.05 (break 15 mins)
11.05 11.30 Examples of sensitivity analysis results (Stefano)
11:30 -12:30 Sensitivity Auditing (**Andrea 60m**)
Conclusions (with Paul) 12:30 – 12:45

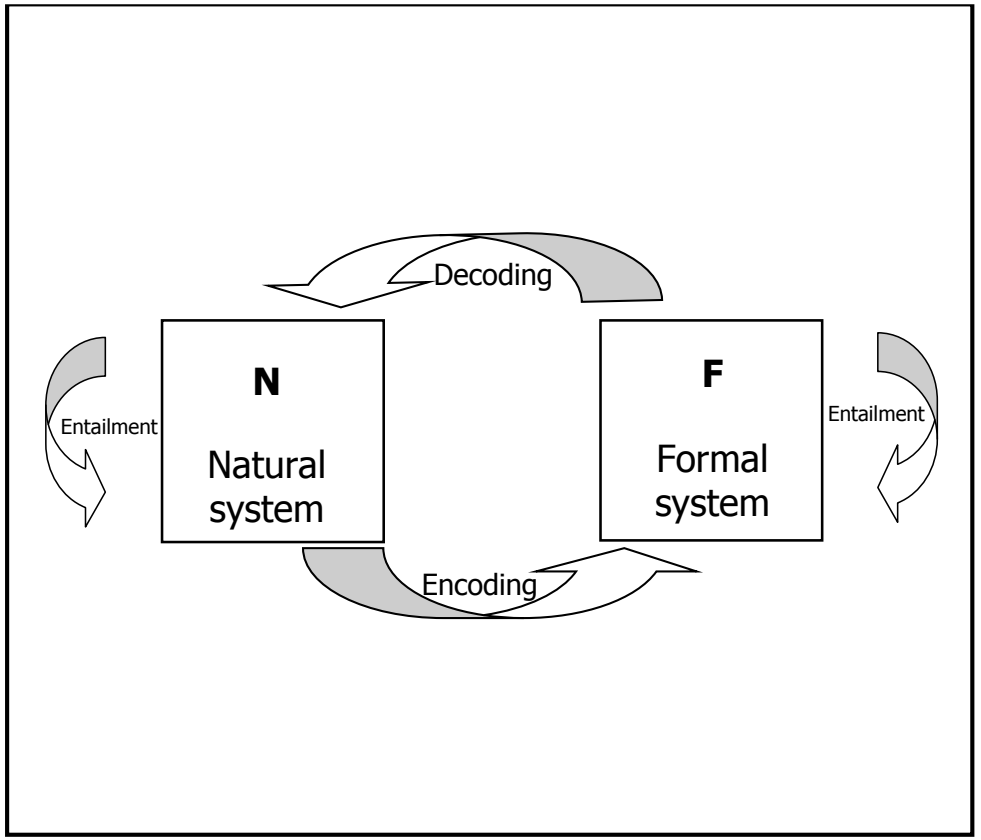
www.andreasaltelli.eu

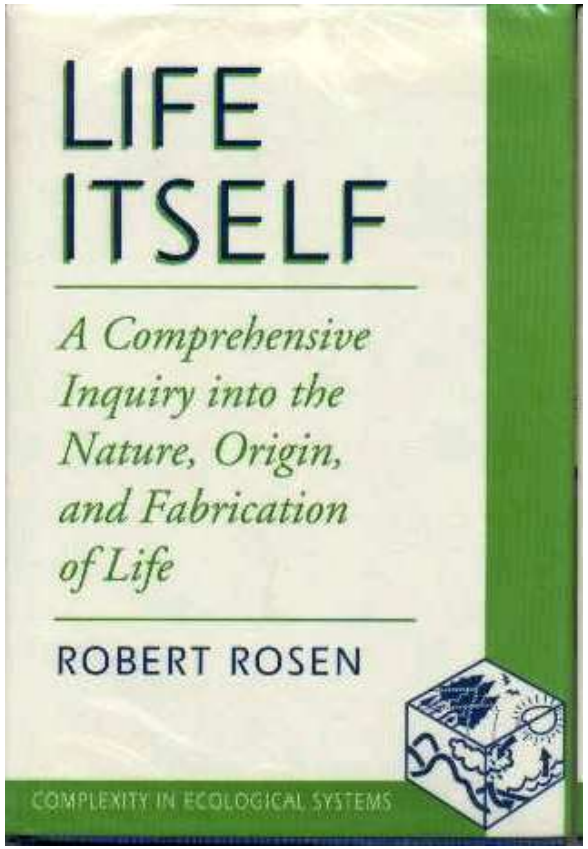
Where to find this talk:



Modelling is a craft more than a science

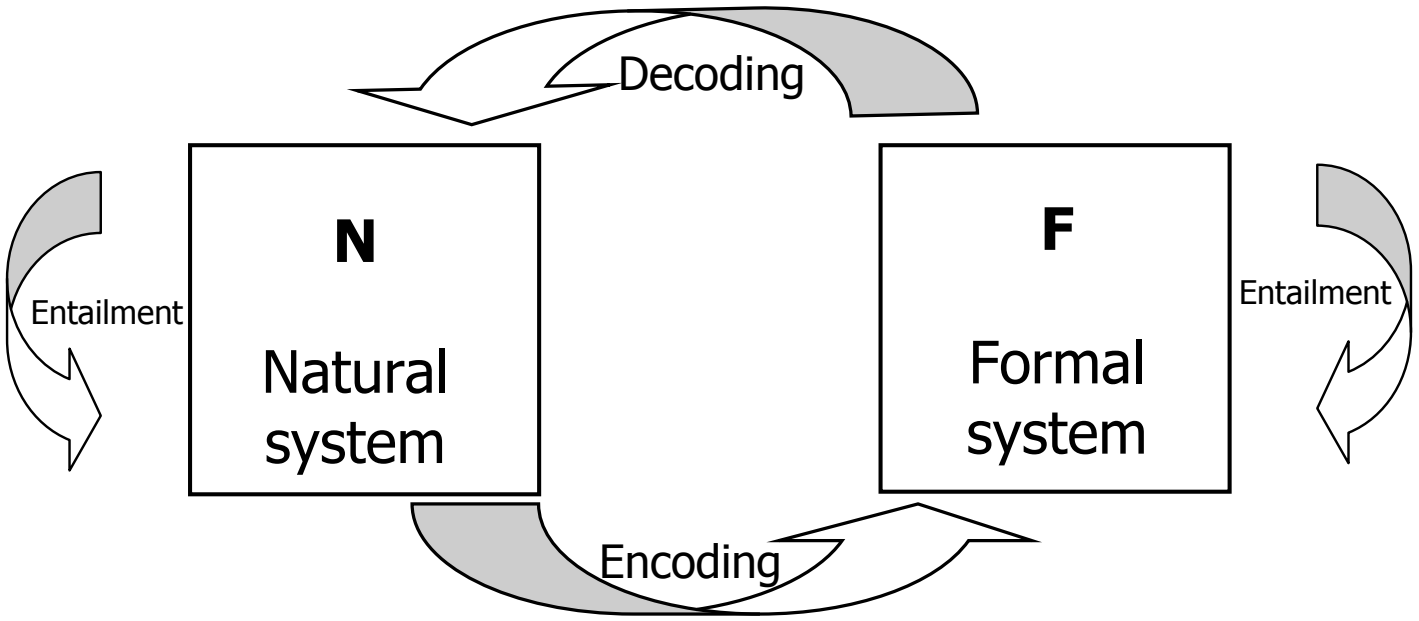
Modelling as a craft rather than as a science for Robert Rosen





R. Rosen, Life Itself: A Comprehensive Inquiry Into the Nature, Origin, and Fabrication of Life. Columbia University Press, 1991.

Louie, A.H. 2010. “Robert Rosen’s Anticipatory Systems.” Edited by Riel Miller. Foresight 12 (3): 18–29. https://doi.org/10.1108/14636681011049848.



What is a model ?

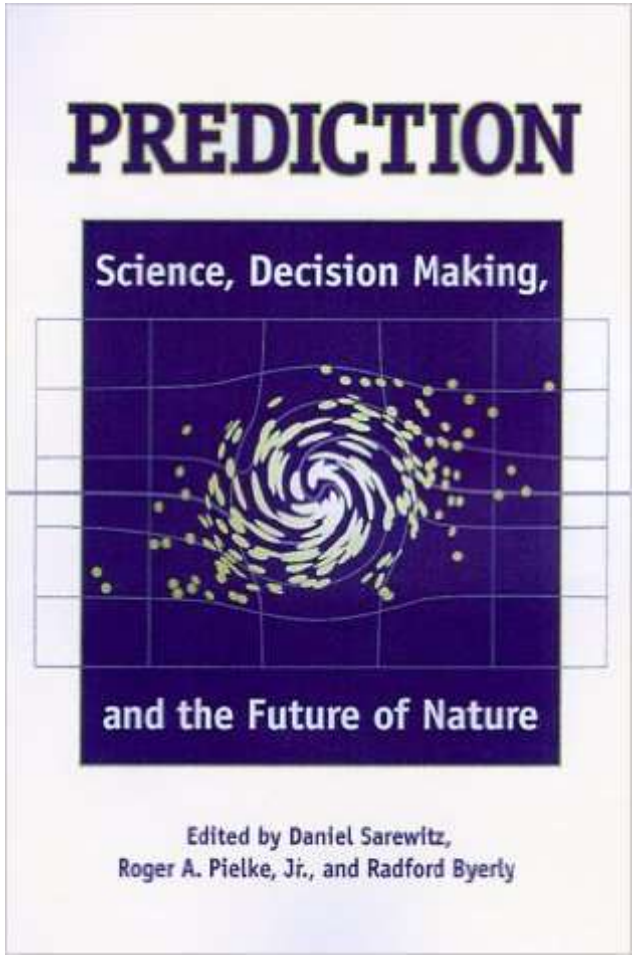
Robert Rosen

“models are most useful when they are used to challenge existing formulations, rather than to validate or verify them”

Naomi Oreskes

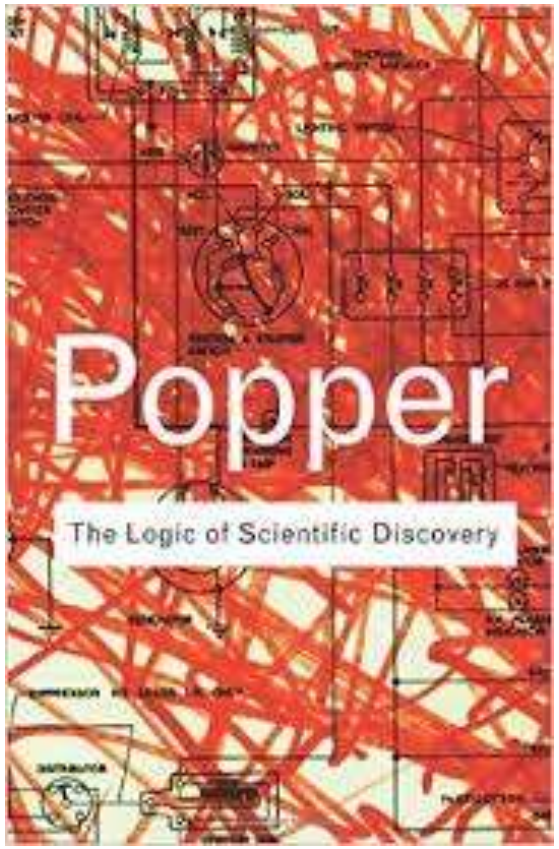
N. Oreskes, K. Shrader-Frechette, and K. Belitz, “Verification, Validation, and Confirmation of Numerical Models in the Earth Sciences,” Science, 263, no. 5147, 1994.

Models are not physical laws



Oreskes, N., 2000, Why predict? Historical perspectives on prediction in Earth Science, in Prediction, Science, Decision Making and the future of Nature, Sarewitz et al., Eds., Island Press, Washington DC

“[…] to be of value in theory testing, the predictions involved must be capable of refuting the theory that generated them”
(N. Oreskes)



“When a model generates a prediction, of what precisely is the prediction a test? The laws? The input data? The conceptualization?

Any part (or several parts) of the model might be in error, and there is no simple way to determine which one it is”

Models have little memory

“[…] The process of constructing and validating [value-at risk] models is time consuming and detail oriented; normally even the people who produced the model will not remember many of the assumptions incorporated into it, short of redoing their work, which means that the client cannot simply ask then what went into it.”

E. Millgram The Great Endarkenment, p. 29

Caeteris are never paribus

Ceteris paribus or caeteris paribus is a Latin phrase meaning "all other things being equal" or "other things held constant" or "all else unchanged“ (Wikipedia)

The case of DSGE, dynamic stochastic general equilibrium models

Rational expectations of agents
Efficient market hypothesis

Philip Mirowski

Philip Mirowski, 2013, Never let a serious crisis go wasted, Verso Books.

The US senate and Queen Elisabeth perplexed…

Philip Mirowski, 2013, Never let a serious crisis go wasted, Verso Books.

Dangers of mathematization of economics

Wolfgang Drechsler

Erik S. Reinert

Paul Romer

Philip Mirowski

W. Drechsler, “On the possibility of quantitative-mathematical social science, chiefly economics,” *J. Econ. Stud.*, vol. 27, no. 4/5, pp. 246–259, 2000.

E. S. Reinert, “Full circle: economics from scholasticism through innovation and back into mathematical scholasticism,” *J. Econ. Stud.*, vol. 27, no. 4/5, pp. 364–376, Aug. 2000.

P. Romer, “Mathiness in the Theory of Economic Growth,” *Am. Econ. Rev.*, vol. 105, no. 5, pp. 89–93, May 2015.

Mirowski, Philip. 2013. Never Let a Serious Crisis Go to Waste: How Neoliberalism Survived the Financial Meltdown. Verso.

IIPP UCL Institute for Innovation and Public Purpose

UCL

WORKING PAPER
WP 2021/07

Altered States: Cartesian and Ricardian dreams

Erik S. Reinert
Tallinn University of Technology
UCL Institute for Innovation and Public Purpose

Monica di Fiore
Institute for Cognitive Sciences and Technologies, Consiglio Nazionale delle Ricerche

Andrea Saltelli
Open Evidence Research, Universitat Oberta de Catalunya (UOC)

Jerome R. Ravetz
Institute for Science, Innovation and Society, University of Oxford

Fishing expeditions, forking paths …

Jorge Luis Borges
(1899-1986)

Taking different narratives within the same novel like Ts'ui Pên

The garden of forking paths: Why multiple comparisons can be a problem, even when there is no "fishing expedition" or "p-hacking" and the research hypothesis was posited ahead of time*

Andrew Gelman† and Eric Loken‡

14 Nov 2013

The garden of forking paths: Why multiple comparisons can be a problem, even when there is no "fishing expedition" or "p-hacking" and the research hypothesis was posited ahead of time*

Andrew Gelman† and Eric Loken‡

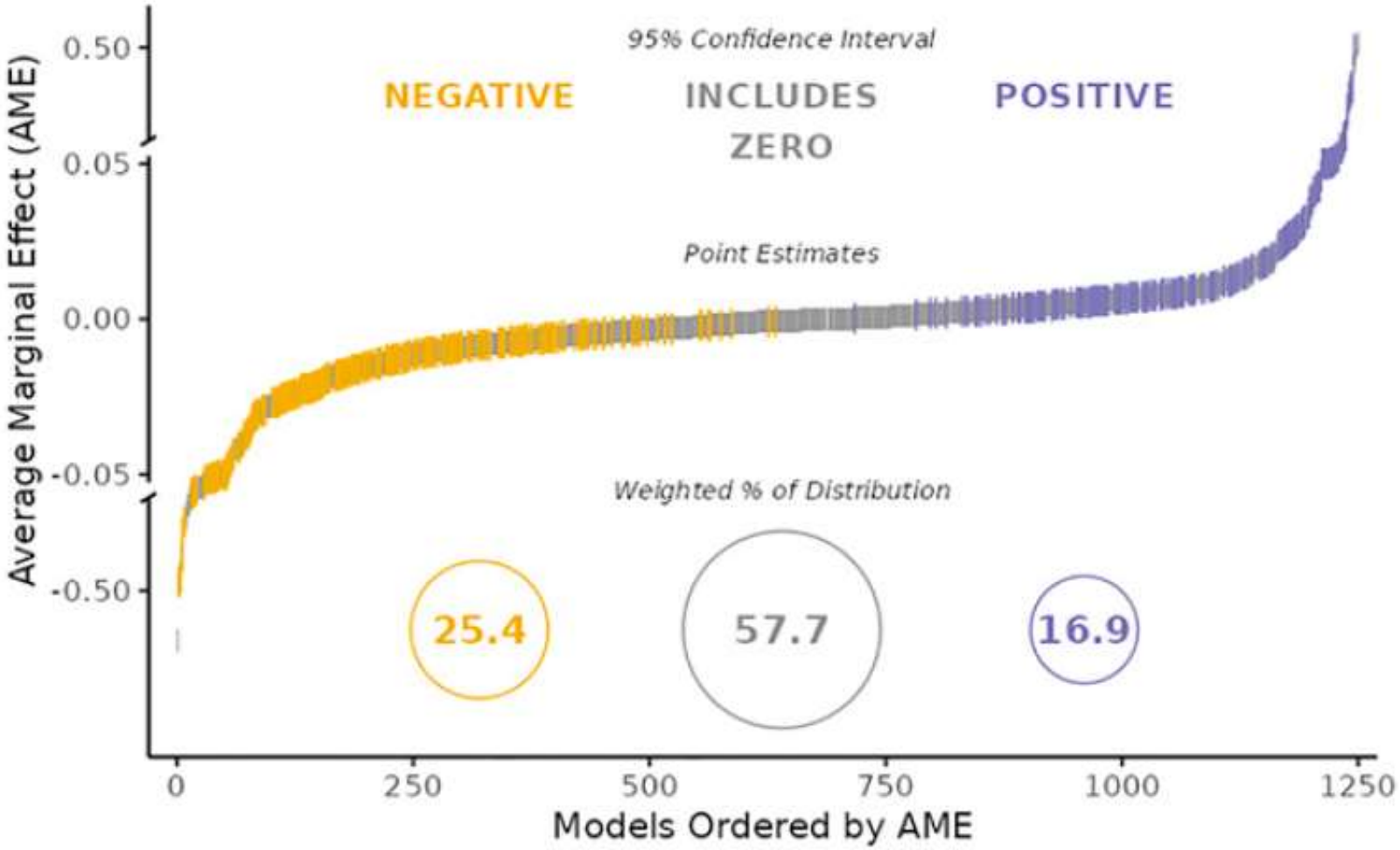
14 Nov 2013

Why this matters?

PNAS RESEARCH ARTICLE | SOCIAL SCIENCES OPEN

Observing many researchers using the same data and hypothesis reveals a hidden universe of uncertainty

Edited by Douglas Massey, Princeton University, Princeton, NJ; received March 6, 2022; accepted August 22, 2022



"Will different researchers [73 teams] converge on similar findings when analyzing the same data?

...

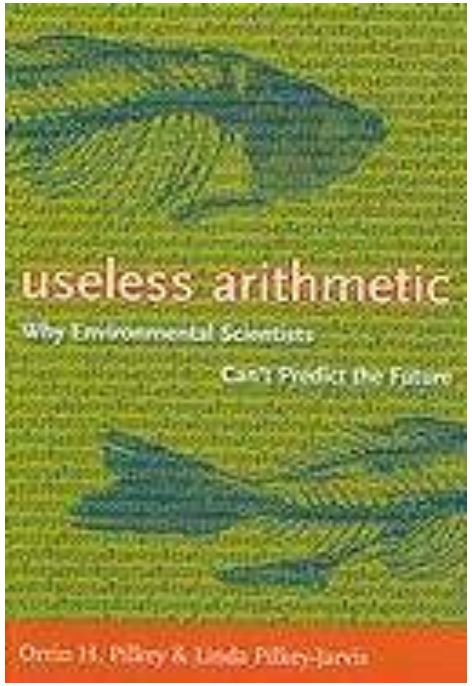
...teams' results varied greatly, ranging from large negative to large positive effects"

(Massey et al. 2022)

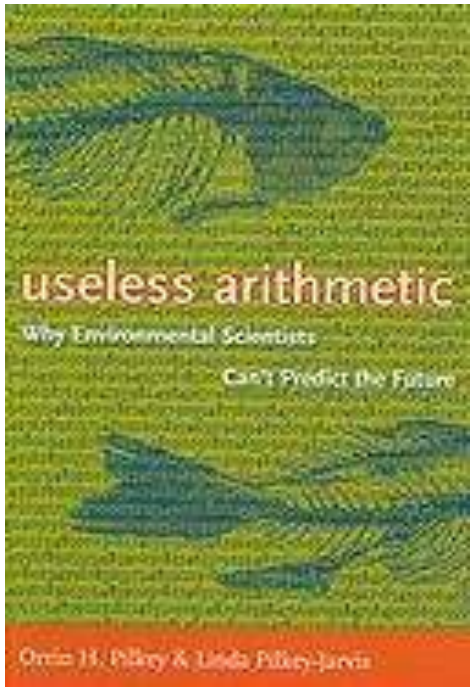
Don’t confuse the map with the territory

If you do, sensitivity analysis will not save you

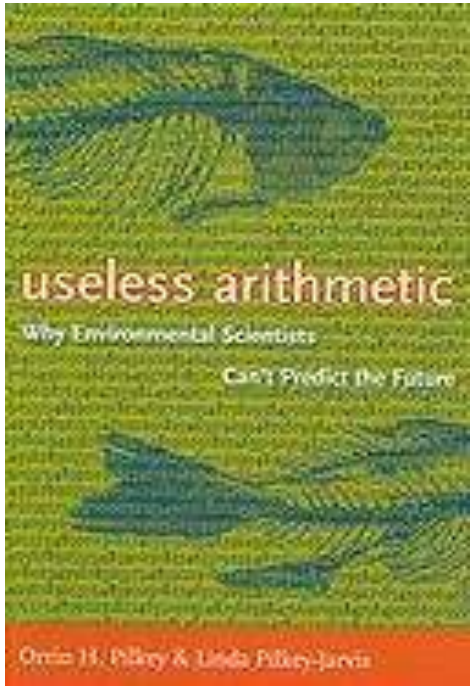
Orrin H.
Pilkey



Useless Arithmetic: Why Environmental Scientists Can't Predict the Future by Orrin H. Pilkey and Linda Pilkey-Jarvis, Columbia University Press, 2009.



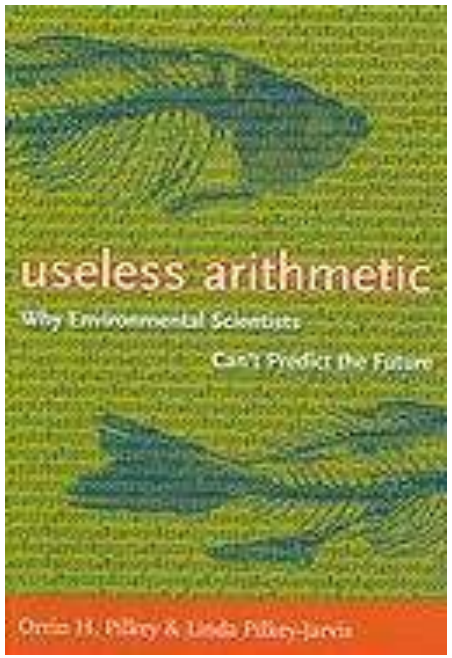
<<It is important, however, to recognize that the sensitivity of the parameter in the equation is what is being determined, not the sensitivity of the parameter in nature>>

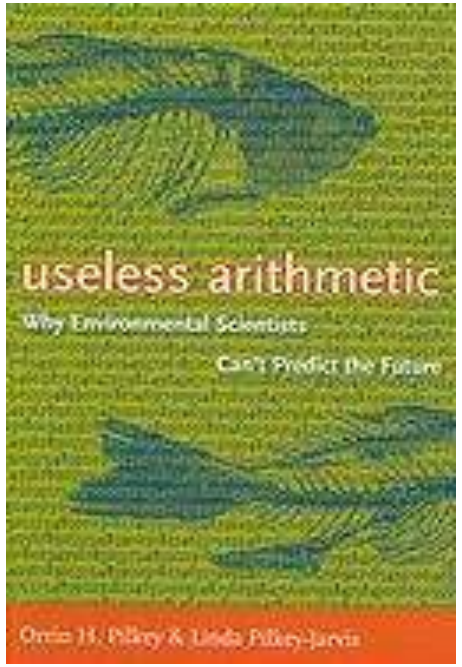


<<…If the model is wrong or if it is a poor representation of reality, determining the sensitivity of an individual parameter in the model is a meaningless pursuit>>

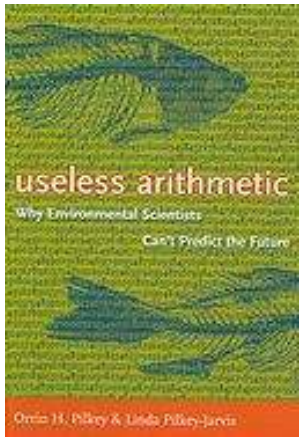
One of the examples discussed concerns the Yucca Mountain repository for radioactive waste. TSPA model (for total system performance assessment) for safety analysis.

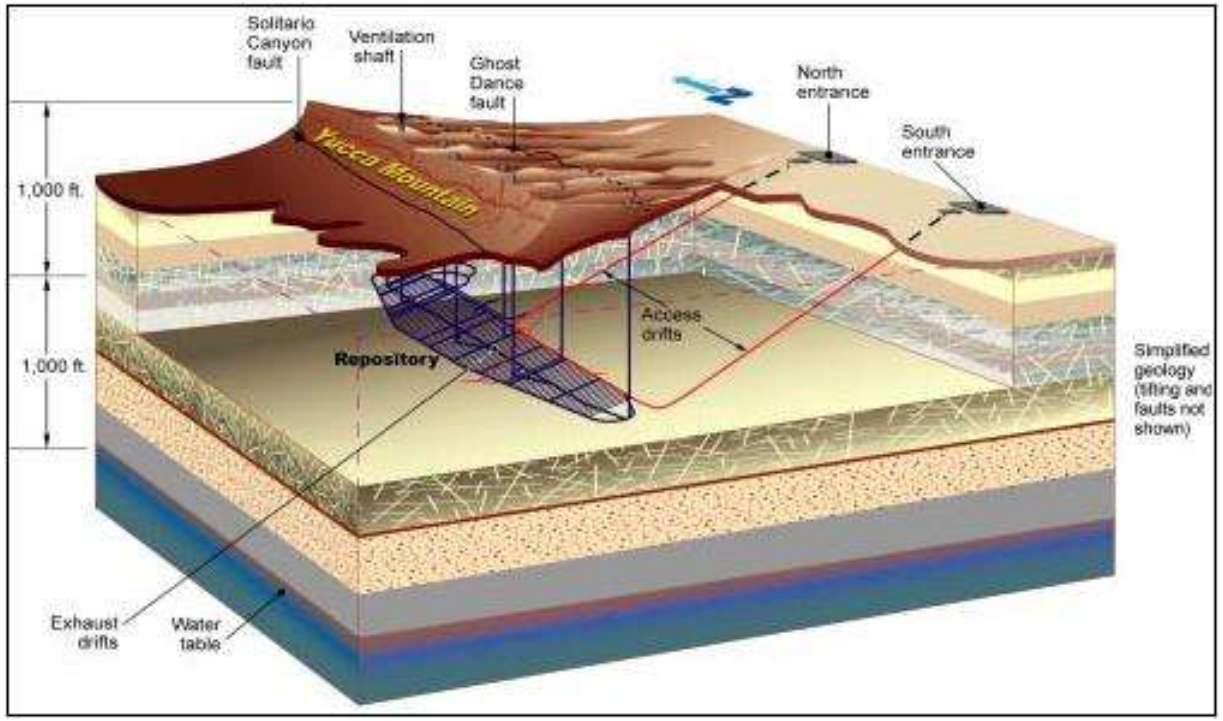
TSPA is Composed of 286 sub-models.





TSPA (like any other model) relies on assumptions → one is the low permeability of the geological formation → long time for the water to percolate from surface to disposal.





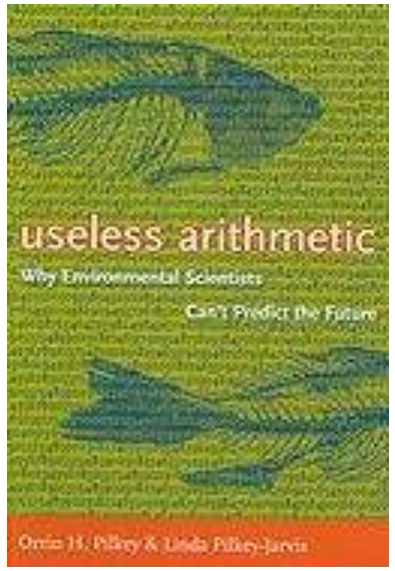
The confidence of the stakeholders in TSPA was not helped when evidence was produced which could lead to an upward revision of 4 orders of magnitude of this parameter

(the ^{36}Cl story)

Type III error in sensitivity: Examples:

In the case of TSPA (Yucca mountain) a range of 0.02 to 1 millimetre per year was used for percolation of flux rate.

→… SA useless if it is instead ~ 3,000 millimetres per year.



"Scientific mathematical modelling should involve constant efforts to falsify the model"

➔Organized skepticism (as per CUDOS)

Communalism, Universalism, Disinterestedness, Organized Skepticism, from sociology of science, Robert K. Merton.

Steve Rayner

Rayner, S., 2012, Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses, Economy and Society, 41:1, 107-125.

Rayner's (2012) strategies to deal with "uncomfortable knowledge".

Denial, Dismissal, Diversion, Displacement

Model based

Rayner, S., 2012, Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses, Economy and Society, 41:1, 107-125.

Displacement: “The model we have developed tells us that real progress is being achieved” (The focus in now the model not the problem).

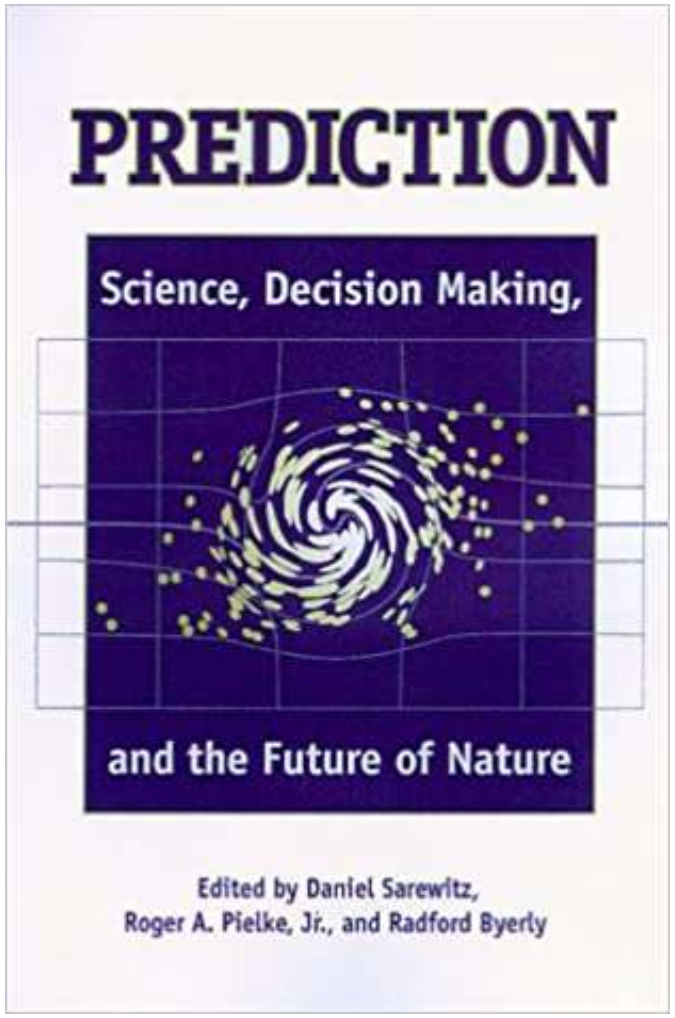
Rayner, S., 2012, Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses, Economy and Society, 41:1, 107-125.

Example of displacement: Chesapeake Bay Program (CBP) modelling work

"Bay models are used to track nutrient loads to ensure the cap is not exceeded"

➔The model results – rather than the actual measurements, become the substance of use

Rayner, S., 2012, Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses, Economy and Society, 41:1, 107-125.



Model GENESIS for beach erosion

US Army Corps of Engineers ®

Manipulated to support coastal-engineering projects

It neglected the role of extreme event

Sarewitz, D., Pielke, R. A. & Byerly, R. *Prediction: Science, Decision Making, and the Future of Nature* (Island Press, 2000).

Beware the size of your model

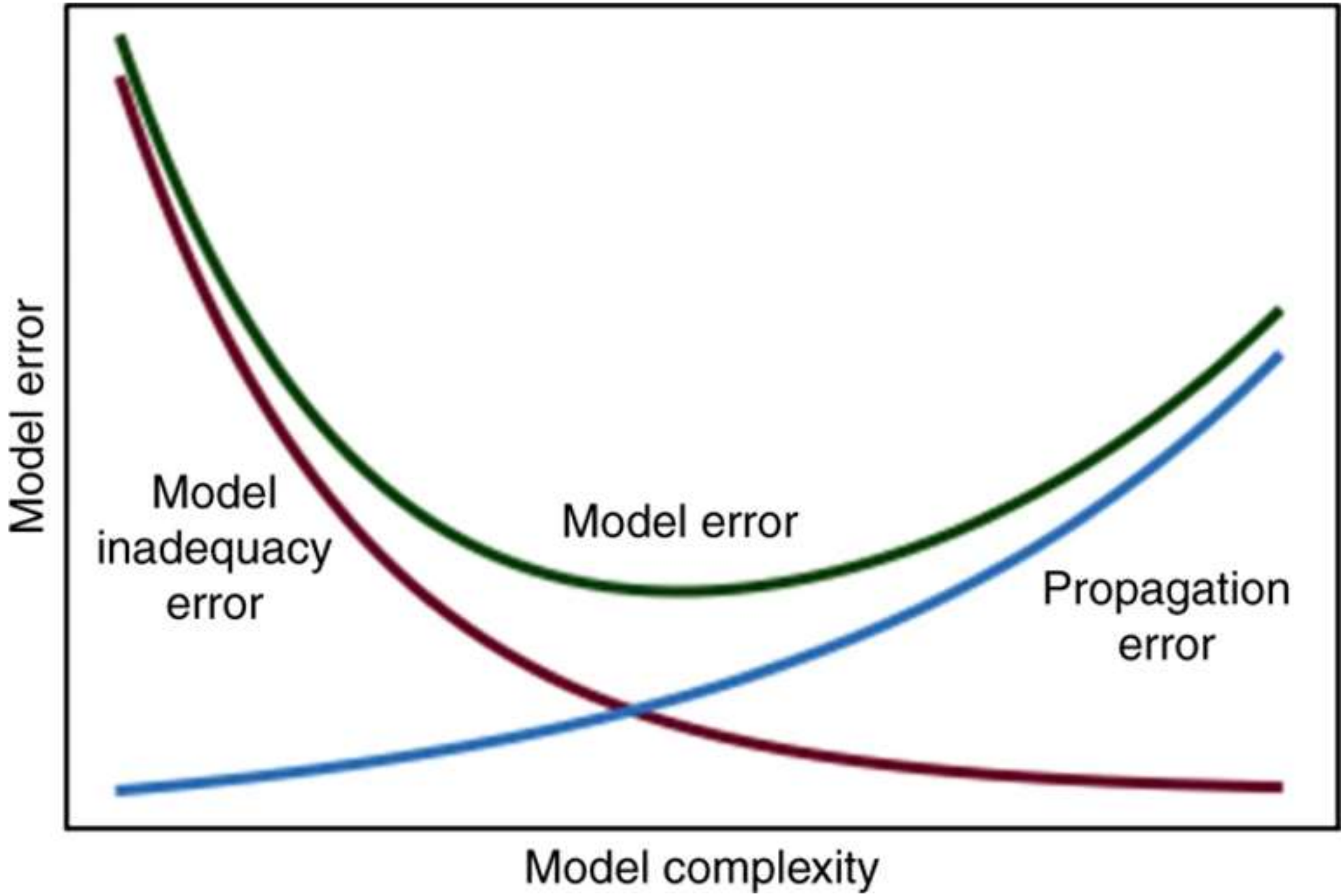
Mind the conjecture of O'Neil

nature COMMUNICATIONS

Comment | Open Access | Published: 27 August 2019

A short comment on statistical versus mathematical modelling

Andrea Saltelli


Model error
Model inadequacy error
Model error
Propagation error
Model complexity

ScienceAdvances

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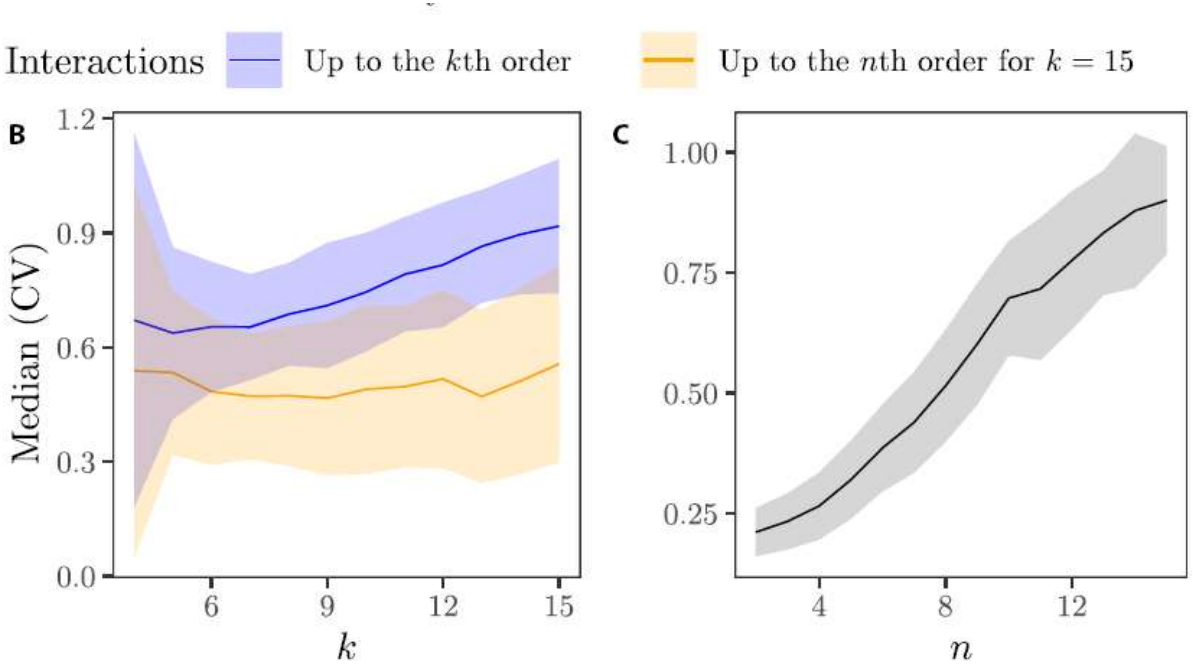
HOME > SCIENCE ADVANCES > VOL. 8, NO. 42 > MODELS WITH HIGHER EFFECTIVE DIMENSIONS TEND TO PRODUCE MORE UNCERTAIN ESTIMATES

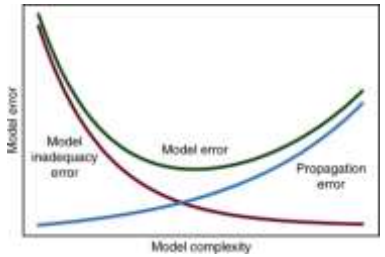
RESEARCH ARTICLE | MATHEMATICS

Models with higher effective dimensions tend to produce more uncertain estimates

ARNALD PUY, PIERFRANCESCO BENEVENTANO, SIMON A. LEVIN, SAMUELE LO PIANO, TOMMASO PORTALURI, AND ANDREA SALTELLI

SCIENCE ADVANCES · 19 Oct 2022 · Vol 8, Issue 42 · DOI: 10.1126/sciadv.abn9450





Empirical test using the SA-based concept of effective dimension

Conjecture by O'Neill, also known as Zadeh's principle of incompatibility, whereby as complexity increases "precision and significance (or relevance) become almost mutually exclusive characteristics"

In M. G. Turner and R. H. Gardner, "Introduction to Models" in Landscape Ecology in Theory and Practice, New York, NY: Springer New York, 2015, pp. 63–95.

L. Zadeh, "Outline of a New Approach to the Analysis of Complex Systems and Decision Processes," IEEE Trans. Syst. Man. Cybern., vol. 3, no. 1, pp. 28–44, 1973.

"…the choice to go for a smaller amount of inputs should be supported with a broader global analysis first to avoid skipping important variables" (Mariia Kozlova, Stanford U.)

COMMENT · 24 JUNE 2020

Five ways to ensure that models serve society: a manifesto

Pandemic politics highlight how predictions need to be transparent and humble to invite insight, not blame.

>260 references

SUPPLEMENTARY INFORMATION

1. Additional information and references

Illustration by David Parkins

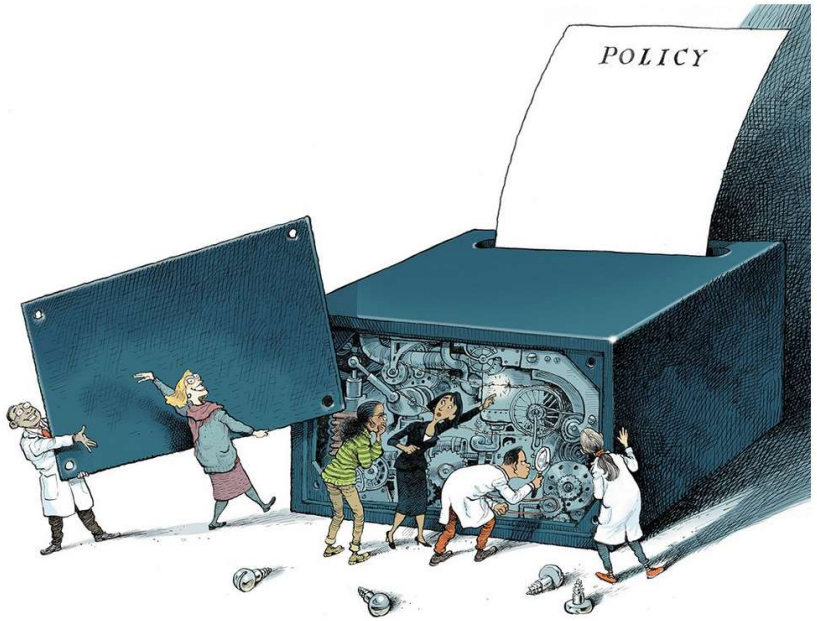
nature

nature

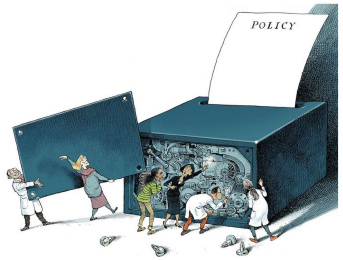
Andrea Saltelli, Gabriele Bammer, Isabelle Bruno, Erica Charters, Monica Di Fiore, Emmanuel Didier, Wendy Nelson Espeland, John Kay, Samuele Lo Piano, Deborah Mayo, Roger Pielke Jr, Tommaso Portaluri, Theodore M. Porter, Arnald Puy, Ismael Rafols, Jerome R. Ravetz, Erik Reinert, Daniel Sarewitz, Philip B. Stark, Andrew Stirling, Jeroen van der Sluijs & Paolo Vineis

3 modellers Lo Piano, Puy, Saltelli
2 experts models and society Pielke, van der Sluijs
3 statisticians Mayo, Stark, Portaluri
2 statactivistes Bruno, Didier
2 economists Kay, Raynert
1 epidemiologist Vineis

2 sociologists of quantification Espeland, Porter
3 STS scholars Bammer, Sarewitz, Stirling
1 philosopher Ravetz
1 historian Charters
1 political scientists Di Fiore
1 expert RRI - Open Science Rafols



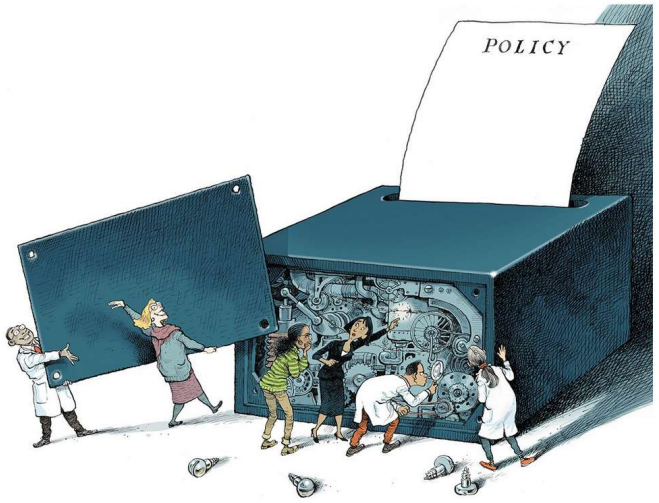
COVID-19 policies dictated by ‘science’ with two digits precision in the presence of fundamental uncertainties



Undocumented research code used as a policy tool (chameleon models)

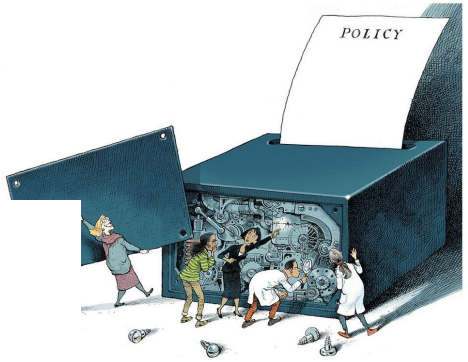
Pfleiderer, P. Chameleons: The Misuse of Theoretical Models in Finance and Economics. *Economica* **87**, 81–107 (2020).

COVID has put mathematical models in the limelight



➔ Power & controversy

Power



The New York Times

Behind the Virus Report That Jarred the U.S. and the U.K. to Action

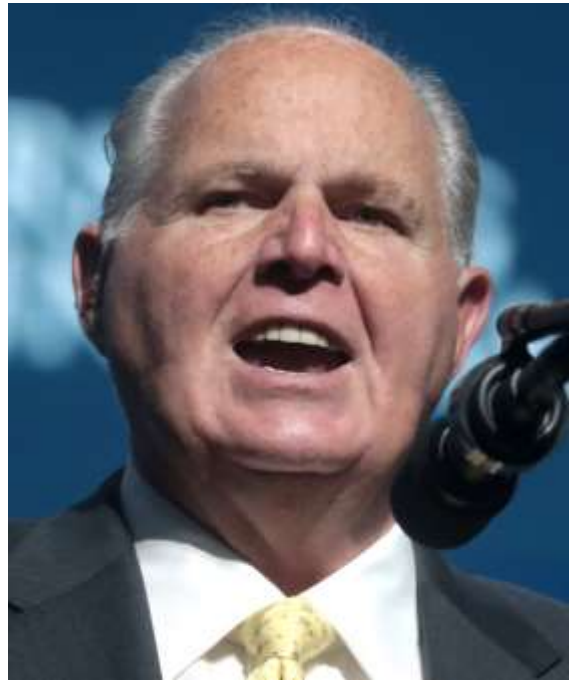
It wasn't so much the numbers themselves, frightening though they were, as who reported them: Imperial College London.

Landler, Mark, and Stephen Castle. 2020. Behind the Virus Report That Jarred the U.S. and the U.K. to Action - The New York Times.

Conflicts, when questions of urgency, stakes, values and uncertainty collide

Rush Limbaugh

"Wild-Ass Covid numbers … The minute I hear anybody start talking about models and modeling, I blanch"



Rhodes, Tim, and Kari Lancaster. 2020. "**Mathematical Models as Public Troubles in COVID-19 Infection Control: Following the Numbers**", Health Sociology Review 1-18. doi: 10.1080/14461242.2020.1764376

Bob Seely slams Imperial College and modelling

UK, conservative MEP.

A 15 m tirade against Imperial College's model and its track record from foot and mouse disease to COVID-19

https://www.indigoumbrella.co.uk/bob-seely-slams-imperial-college-and-modelling/

Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

Complexity can be the enemy of relevance

Mind the framing

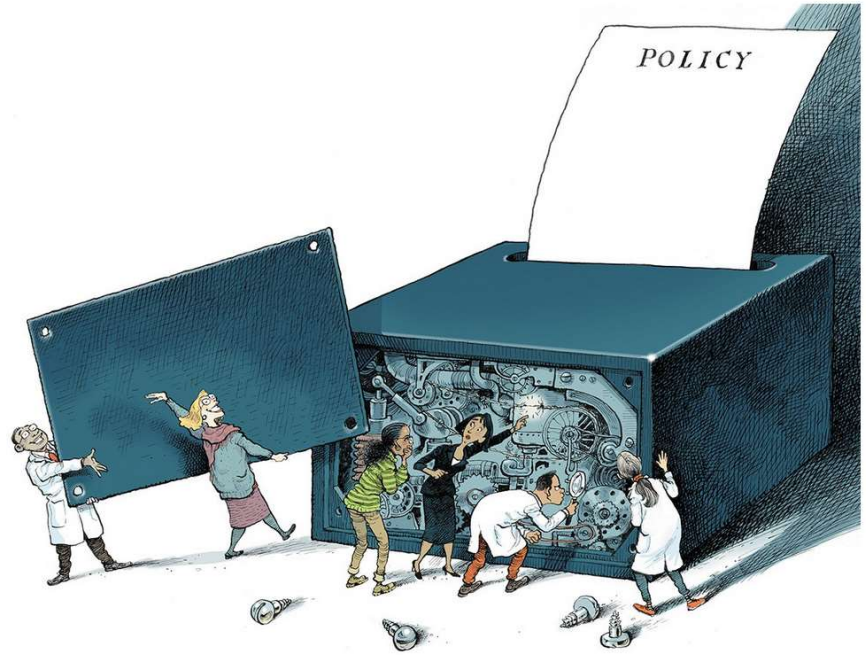
Match purpose and context

Mind the consequences

Quantification can backfire

Mind the unknowns

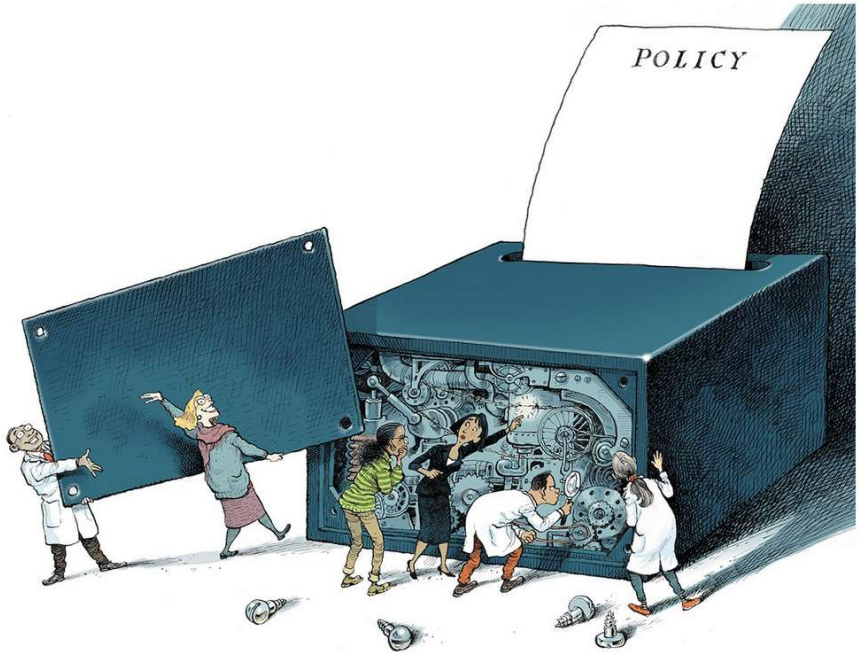
Acknowledge ignorance



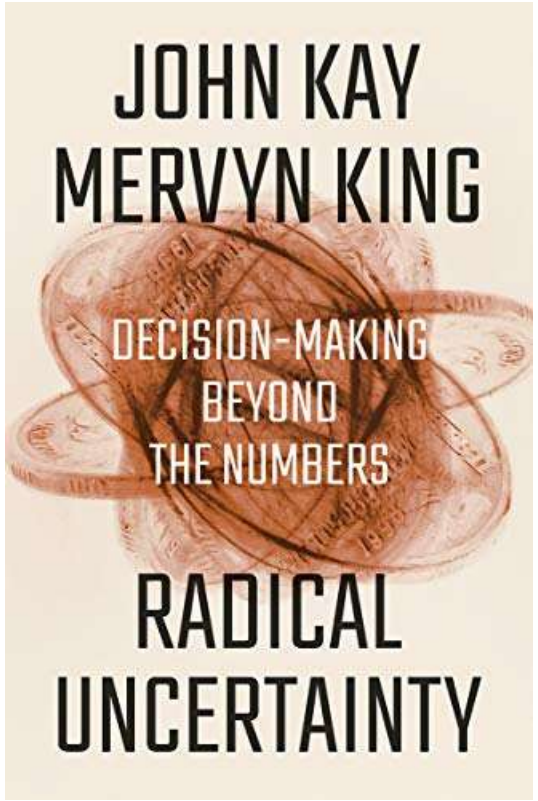
Mind the assumptions

Assess uncertainty and sensitivity

… models require input values for which there is no reliable information…



Models ask as input information which we don't have – The case of WEBTAG



John Kay

WebTAG: Annual Percentage Change in Car Occupancy (% pa) up to 2036

Journey Purpose	Weekday					Weekend	All Week
	7am-10am	10am-4pm	4pm-7pm	7pm-7am	Weekday Average		
Work	-0.48	-0.4	-0.62	-0.5	-0.44	-0.48	-0.45
Non - Work (commuting and other)	-0.67	-0.65	-0.53	-0.47	-0.59	-0.52	-0.56

Source: J. A. Kay, "Knowing when we don't know," 2012, https://www.ifs.org.uk/docs/john_kay_feb2012.pdf

Mind the assumptions

Assess uncertainty and sensitivity

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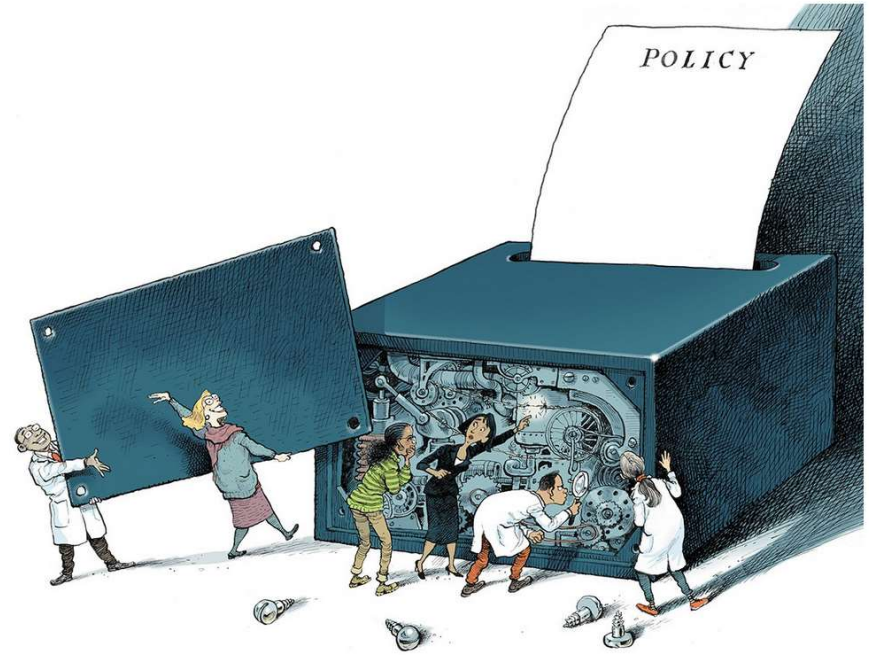
Complexity can be the enemy of relevance



Mind the framing

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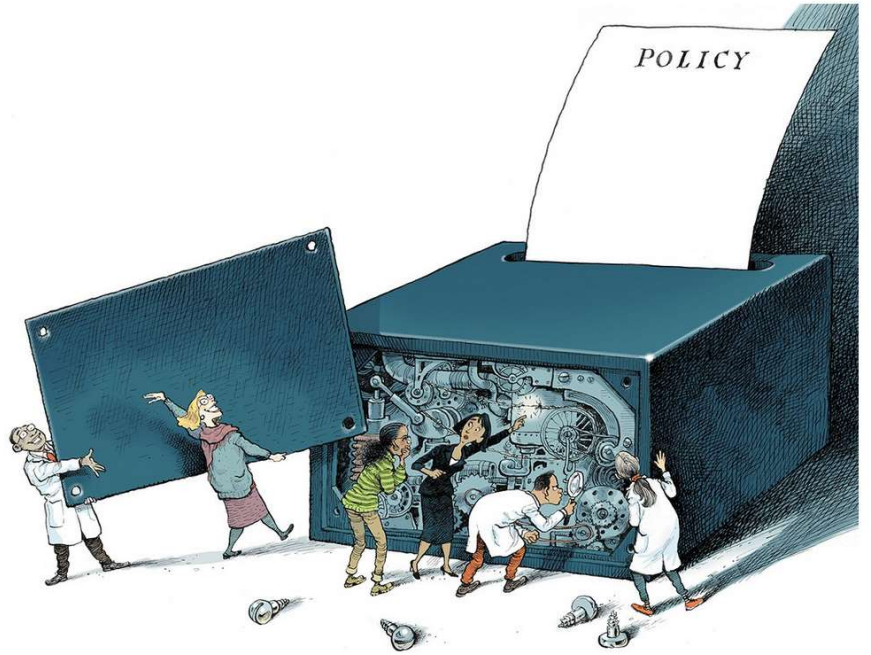
Complexity can be the enemy of relevance

… many are seduced by the idea of adding complexity in an attempt to capture reality more accurately, but …



SUPPLEMENTARY INFORMATION

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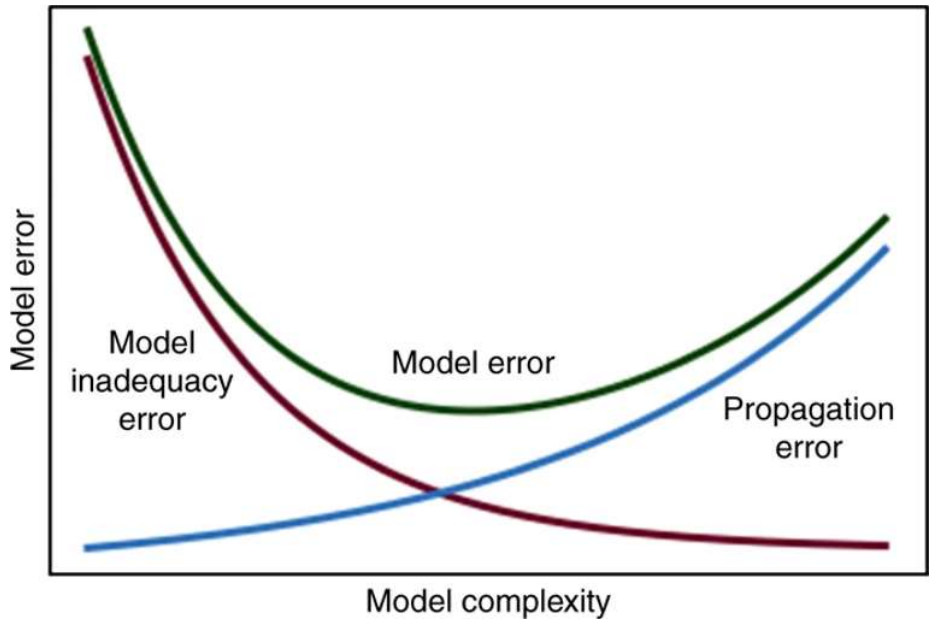

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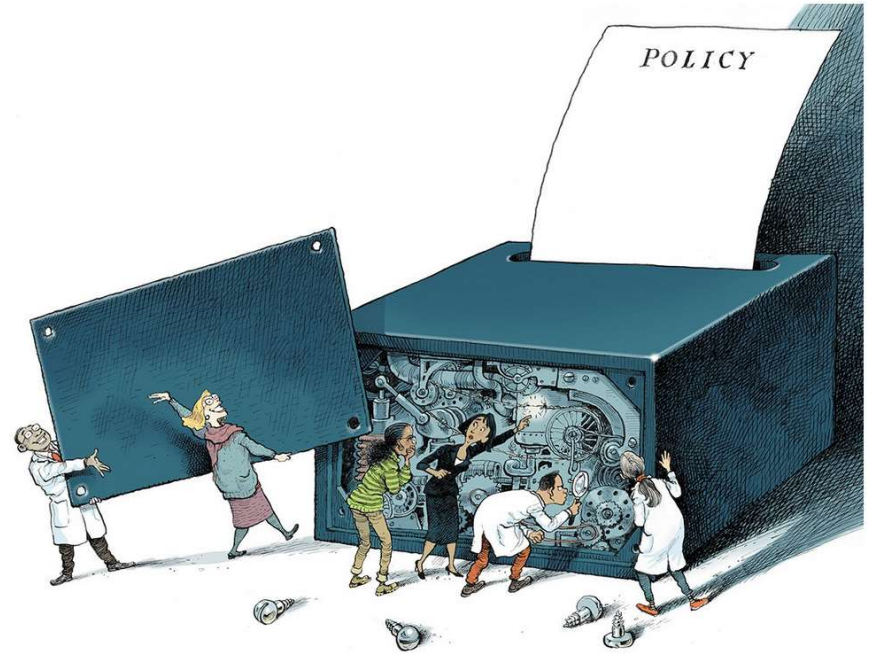
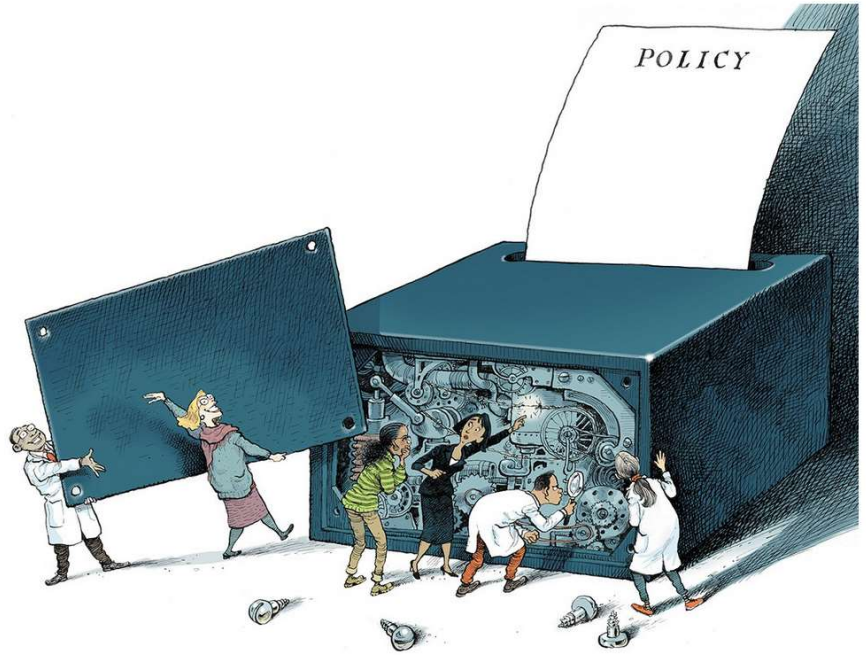


Mind the framing

Match purpose and context



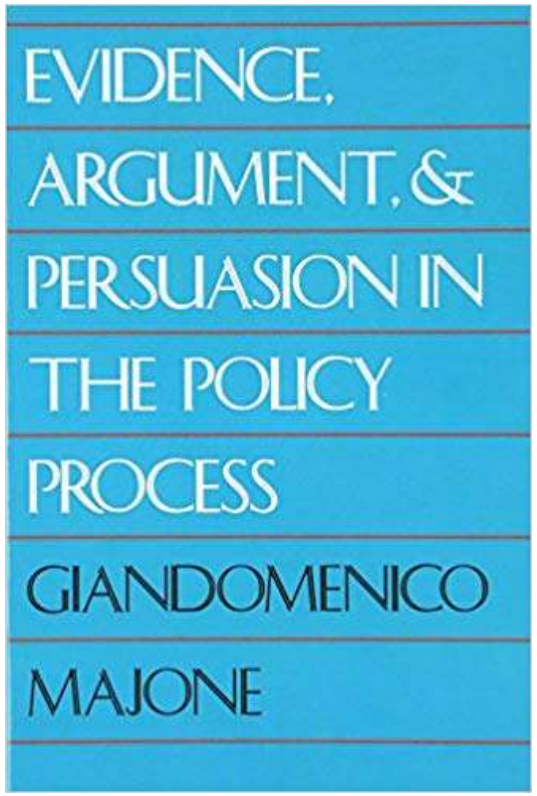
… models will reflect the interests, disciplinary orientations and biases of the developers…

SUPPLEMENTARY INFORMATION

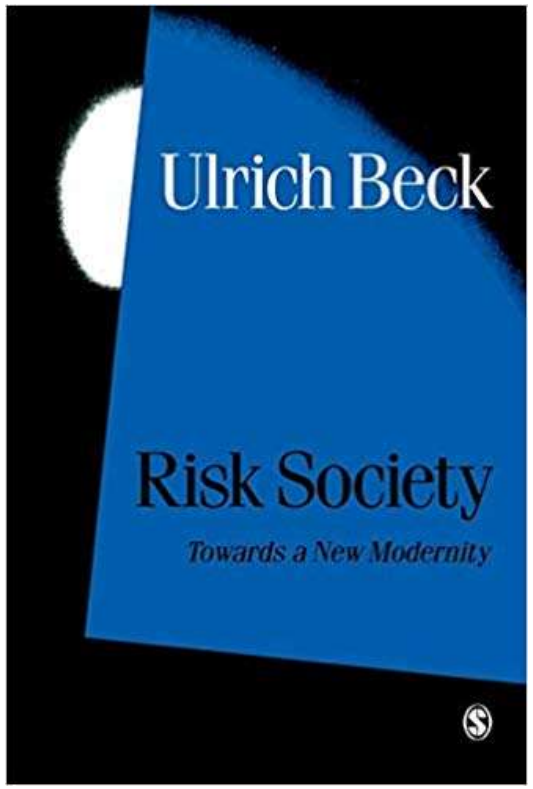
1. Additional information and references >260 references

From Ulrich Beck to Giandomenico Majone: the technique is never neutral

Ulrich Beck
(1944 –2015)



1989



1992 (1986)

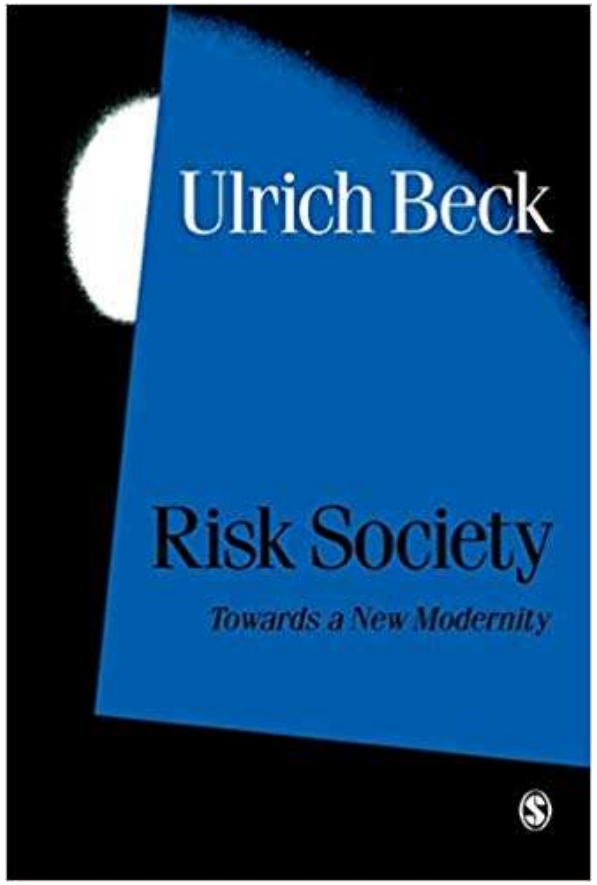
ELSEVIER

Environmental Science & Policy
Volume 106, April 2020, Pages 87-98

The technique is never neutral. How methodological choices condition the generation of narratives for sustainability

Andrea Saltelli [a, b], Lorenzo Benini [c], Silvio Funtowicz [a], Mario Giampietro [d, e], Matthias Kaiser [a], Erik Reinert [a, f], Jeroen P. van der Sluijs [a, g, h]

“It is not uncommon for political programs to be decided in advance simply by the choice of what expert representatives are included in the circle of advisers.”



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Combine more lenses, including Post-normal science (PNS), Bioeconomics, and Non-Ricardian economics

Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

Complexity can be the enemy of relevance

Mind the framing

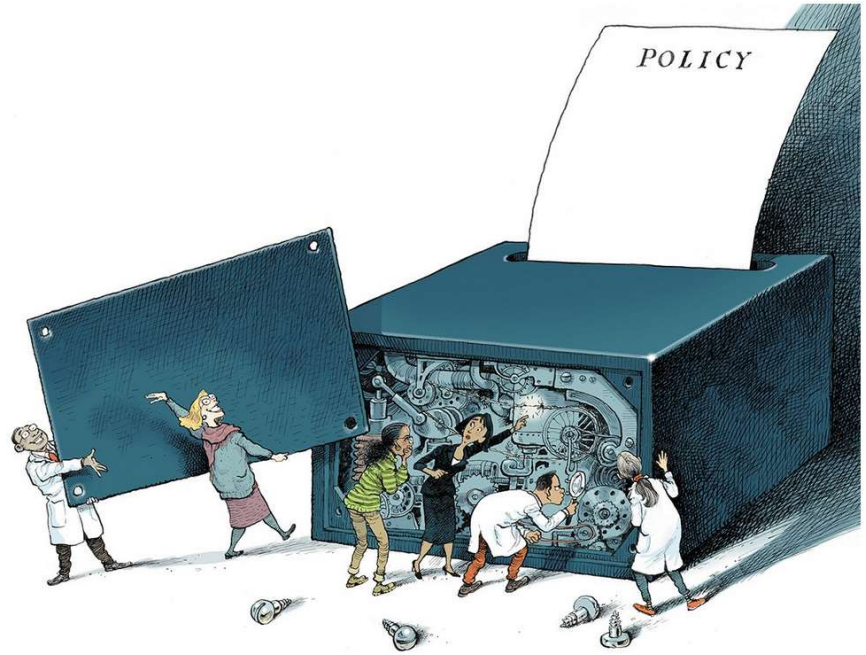
Match purpose and context

Mind the consequences

Quantification can backfire

Mind the unknowns

Acknowledge ignorance



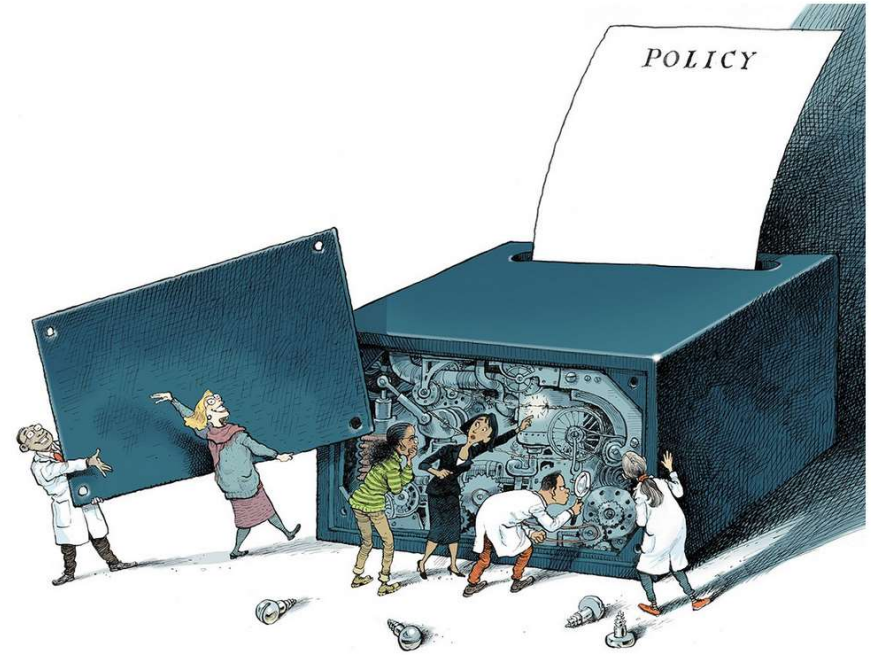
Mind the consequences

Quantification can backfire.

« Back to Article
WIRED MAGAZINE: 17.03

Recipe for Disaster: The Formula That Killed Wall Street

By Felix Salmon 02.23.09



Here's what killed your 401(k) *David X. Li's Gaussian copula function as first published in 2000. Investors exploited it as a quick—and fatally flawed—way to assess risk. A shorter version appears on this month's cover of* Wired.

Here is what killed your 401(k)…

Li's Gaussian copula function …

Nassim Nicholas Taleb, hedge fund manager and author of *The Black Swan*, is particularly harsh when it comes to the copula. "People got very excited about the Gaussian copula because of its mathematical elegance, but the thing never worked," he says. "Co-association between securities is not measurable using correlation," because past history can never prepare you for that one day when everything goes south. "Anything that relies on correlation is charlatanism."

Felix Salmon, Wired, February 2009

WIRED

Source: https://www.wired.com/2009/02/wp-quant/

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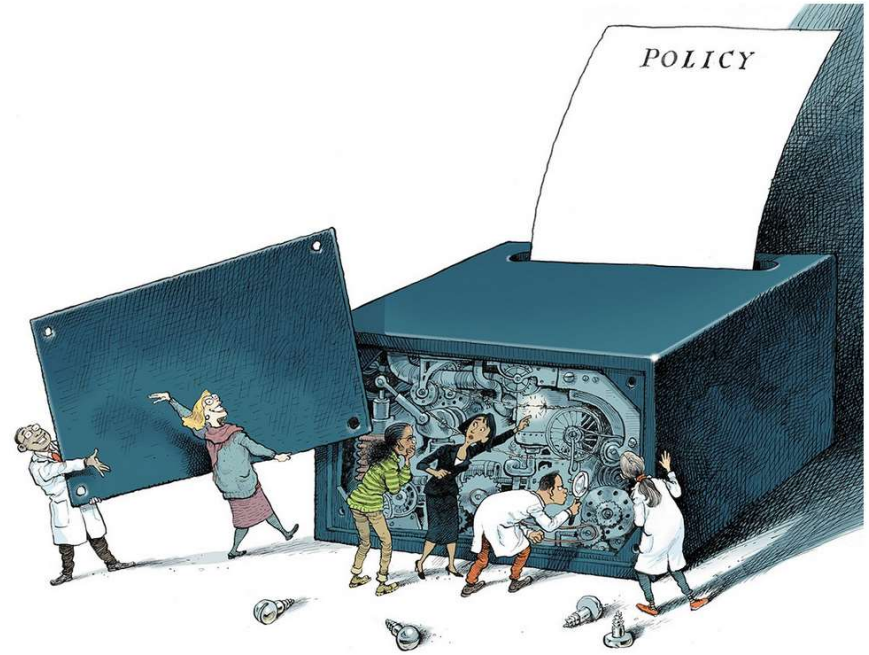

Mind the unknowns

Acknowledge ignorance

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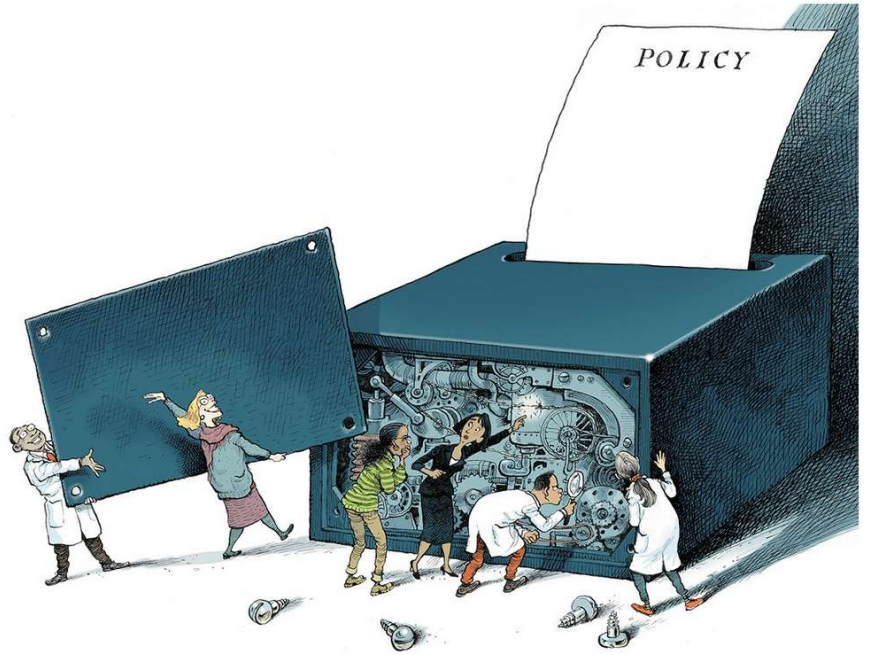
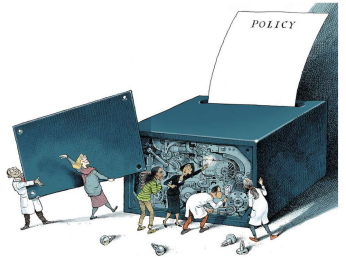


From Socrates's "knowing of not knowing" to Nicolaus Cusanus' Docta Ignorantia was a virtue until Descartes

“There is no number-answer to your question”



Anthony Fauci

March 12, 2020, Anthony Fauci before the House Oversight and Reform Committee
https://archive.org/details/CSPAN_20200314_141500_Dr._Redfield_Dr._Fauci__Others_Testify_on_Coronavirus_Response_Part_1

Reproducibility

is a necessary condition for

Transparency

is a necessary condition for

Legitimacy

is a necessary condition for

Epistemic authority

Important institution

Large model

The End