SA – PART TWO

Sensitivity auditing

Andrea Saltelli
MNF990 PhD course on
Theory of Science and Ethics
February 14, 2022

Where to find this talk: www.andreasaltelli.eu

Something general about mathematical modelling

Modelling is a craft more than a science

Modelling as a craft rather than as a science for Robert Rosen
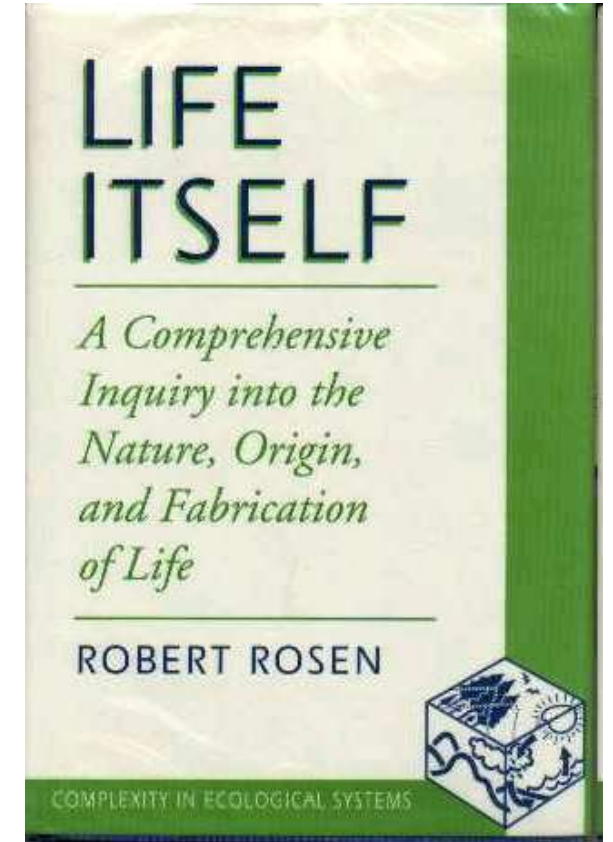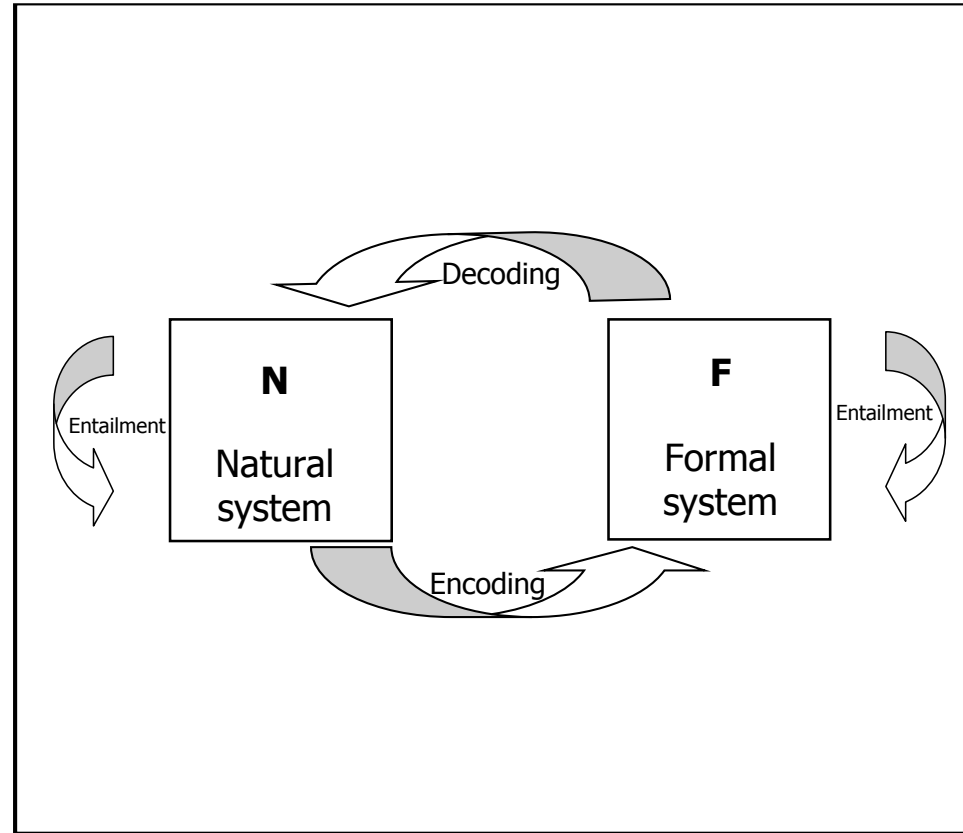
R. Rosen, Life Itself: A Comprehensive Inquiry Into the Nature, Origin, and Fabrication of Life. Columbia University Press, 1991.

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

Decoding

N
Natural system

F
Formal system

Entailment

Entailment

Encoding
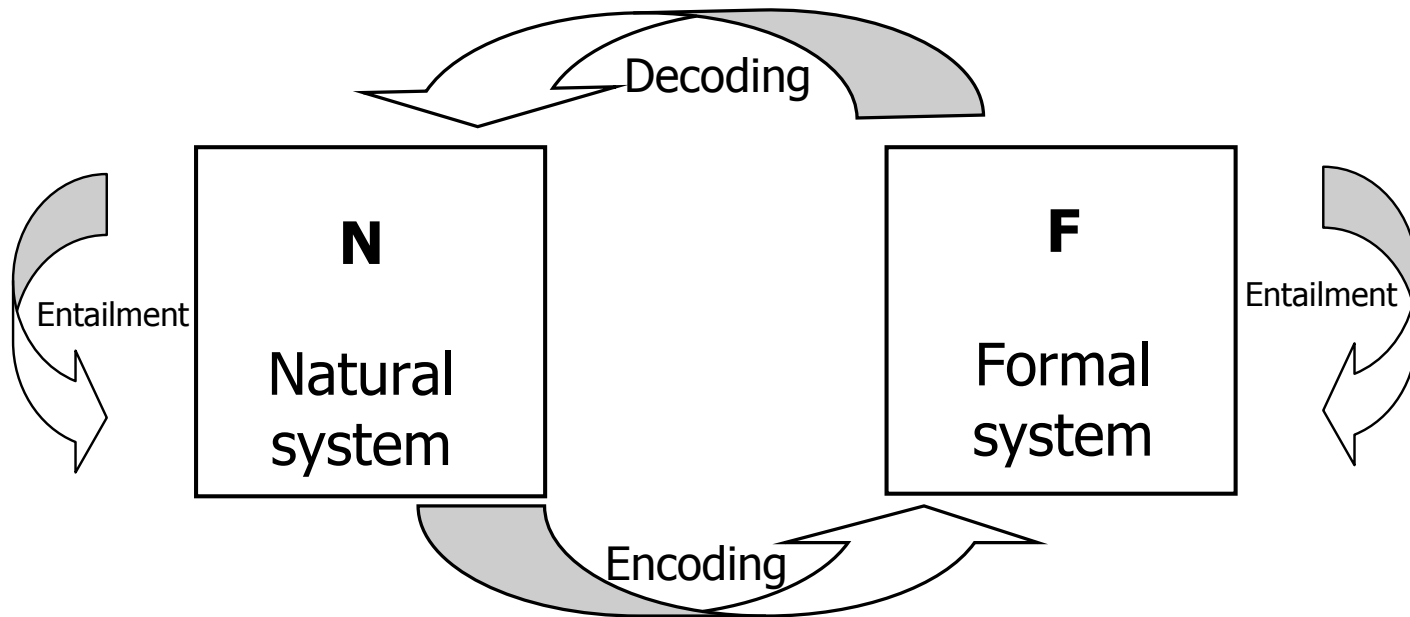
What is a model ?

Robert Rosen

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

Naomi
Oreskes

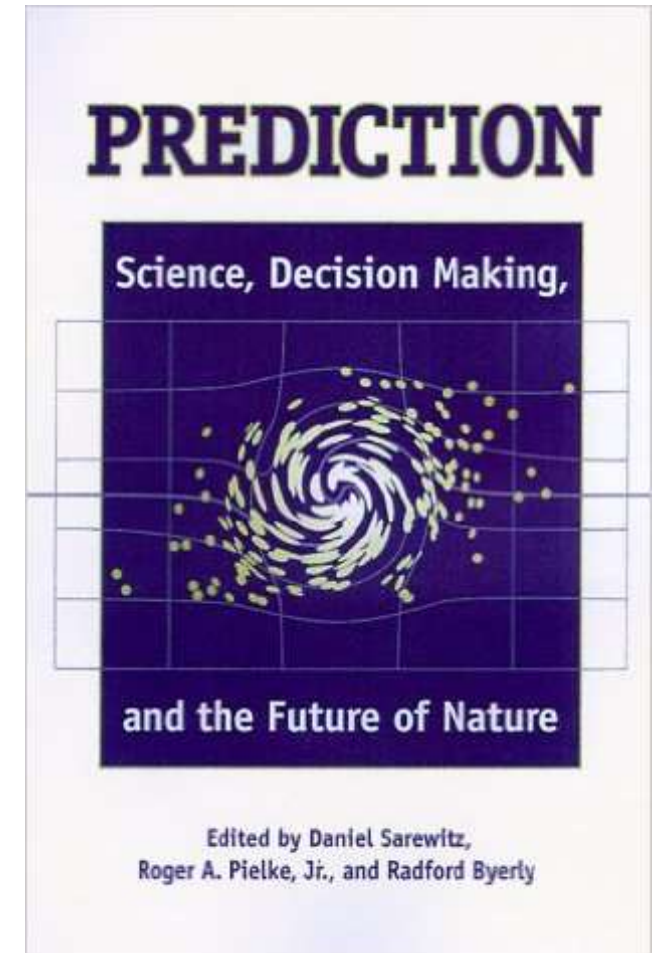N. Oreskes, K. Shrader-Frechette, and K. Belitz, "Verification, Validation, and Confirmation of Numerical Models in the Earth Sciences," Science, 263, no. 5147, 1994.

Models are not physical laws

PREDICTION
Science, Decision Making,
and the Future of Nature

Edited by Daniel Sarewitz,
Roger A. Pielke, Jr., and Radford Byerly

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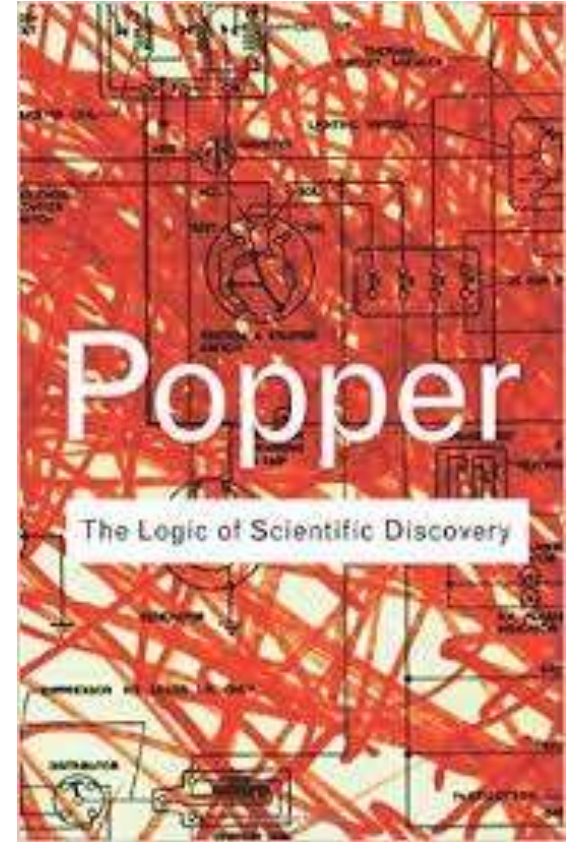
"When a model generates a prediction, of what precisely is the prediction a test? The laws? The input data? The conceptualization?

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.

Need for better modelling?
A manifesto

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

POLICY

Illustration by David Parkins

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

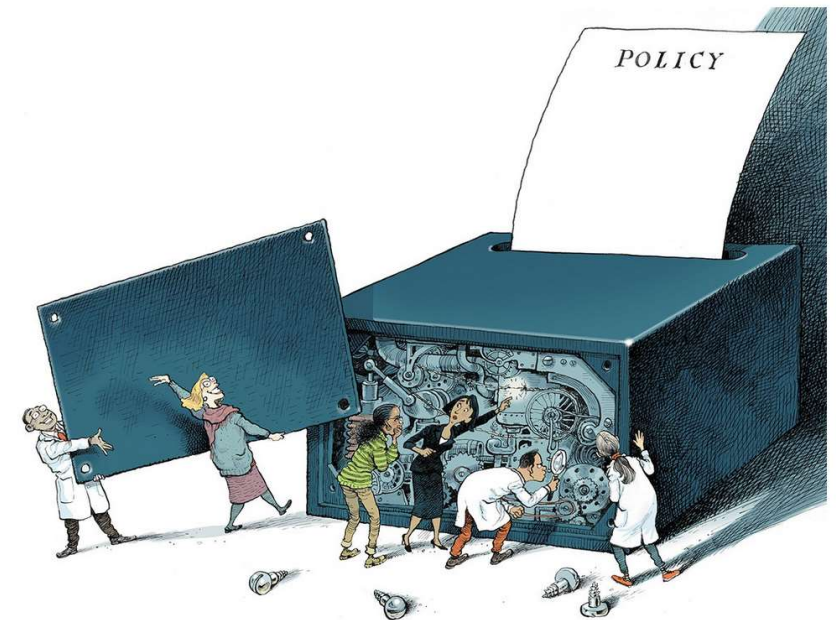2 sociologists of quantification
Espeland, Porter

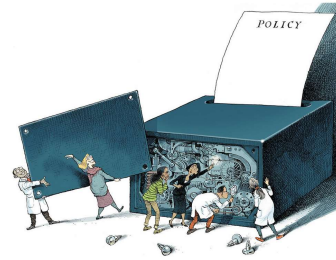3 STS scholars Bammer, Sarewitz, Stirling

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
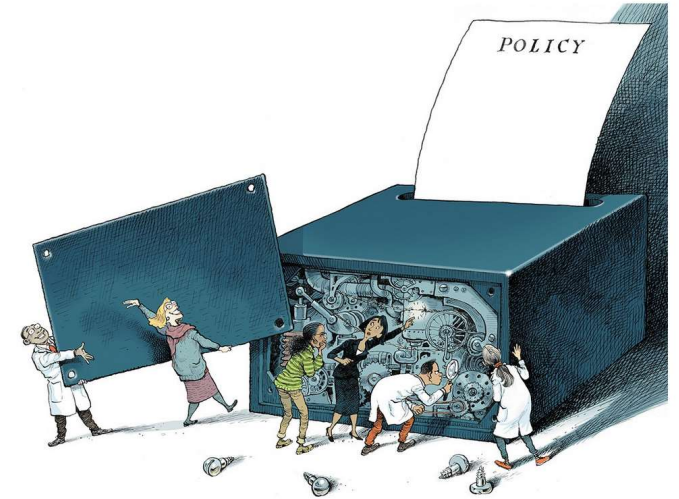

Undocumented research code used as a policy tool (chameleon models)

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

COVID has put mathematical
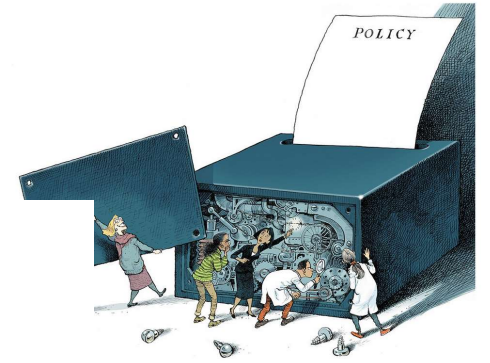models in the limelight

➔ 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

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

Bob Seely slams Imperial College and modelling

UK, conservative MEP.

18.01.22 Covid Forecasting and Modelling Westminster Ha...

Watch Later

Share

Watch on YouTube

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

Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

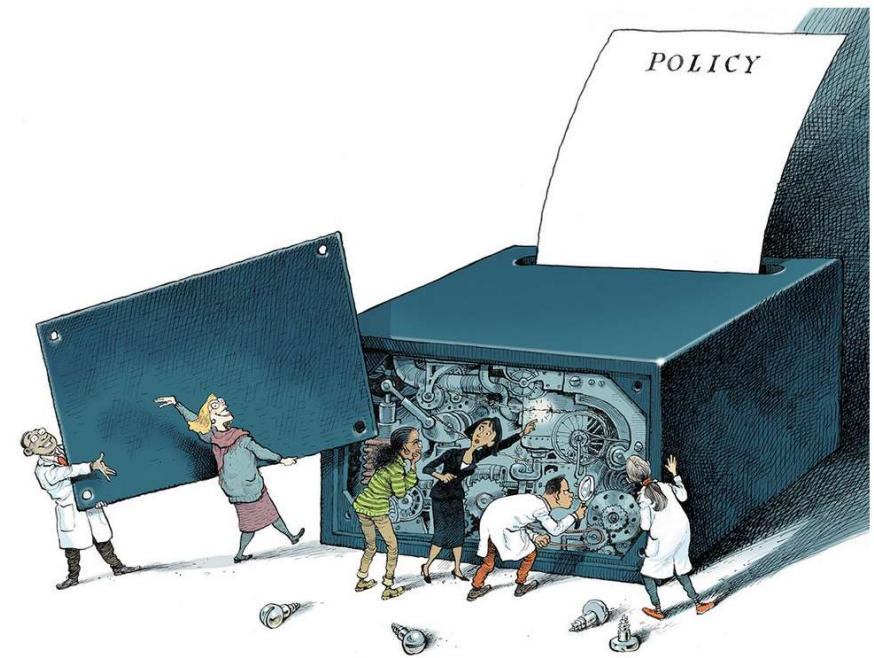Complexity can be the enemy of relevance

Mind the framing

Match purpose and context

Mind the consequences

Quantification can backfire.

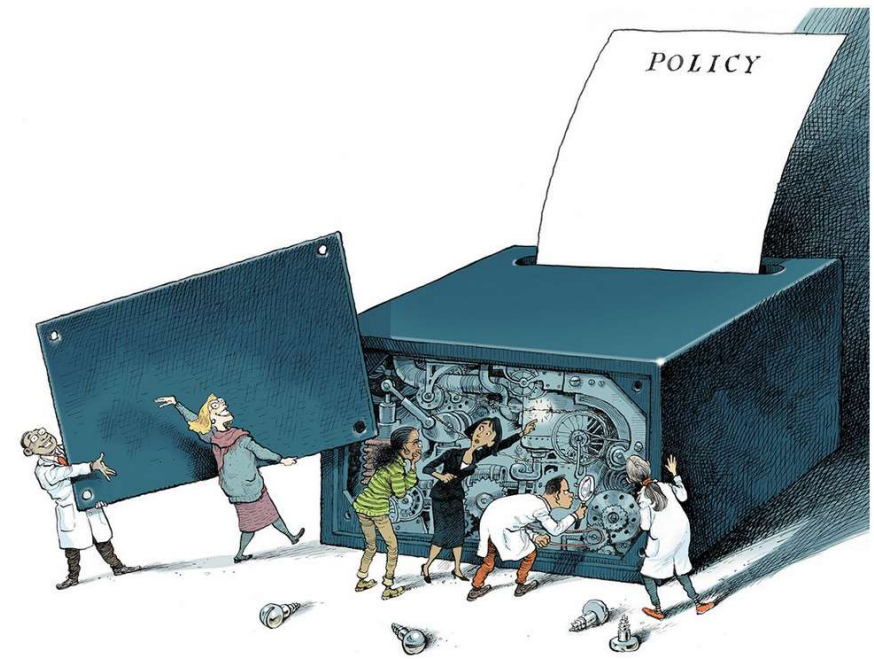## Mind the unknowns
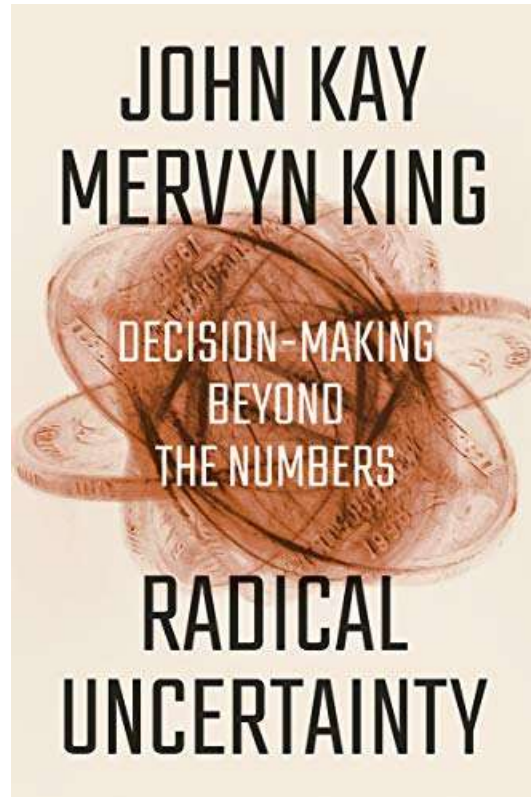
Acknowledge ignorance

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				Weekday Average	Weekend	All Week
	7am-10am	10am-4pm	4pm-7pm	7pm-7am			
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

Mind the hubris ←
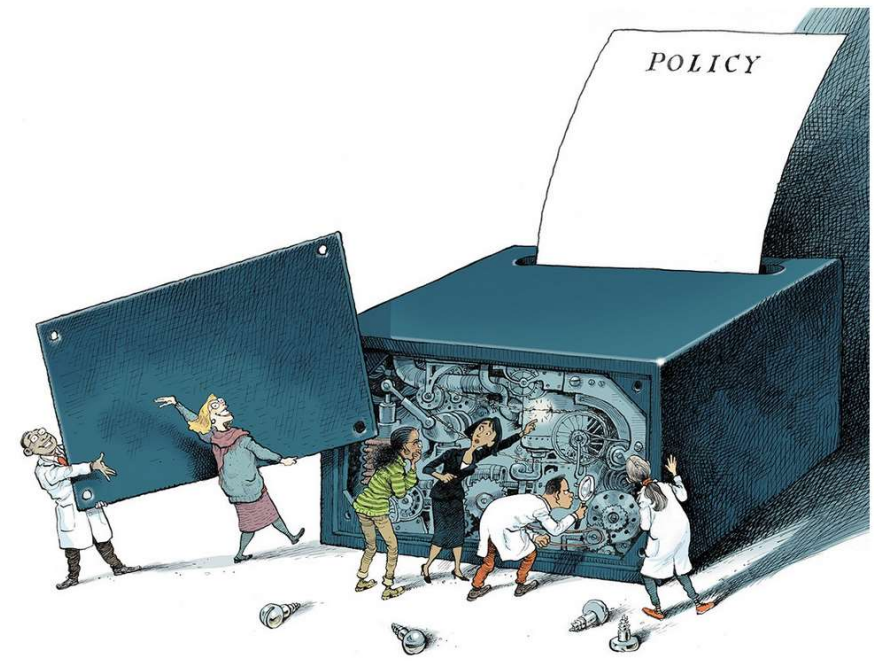
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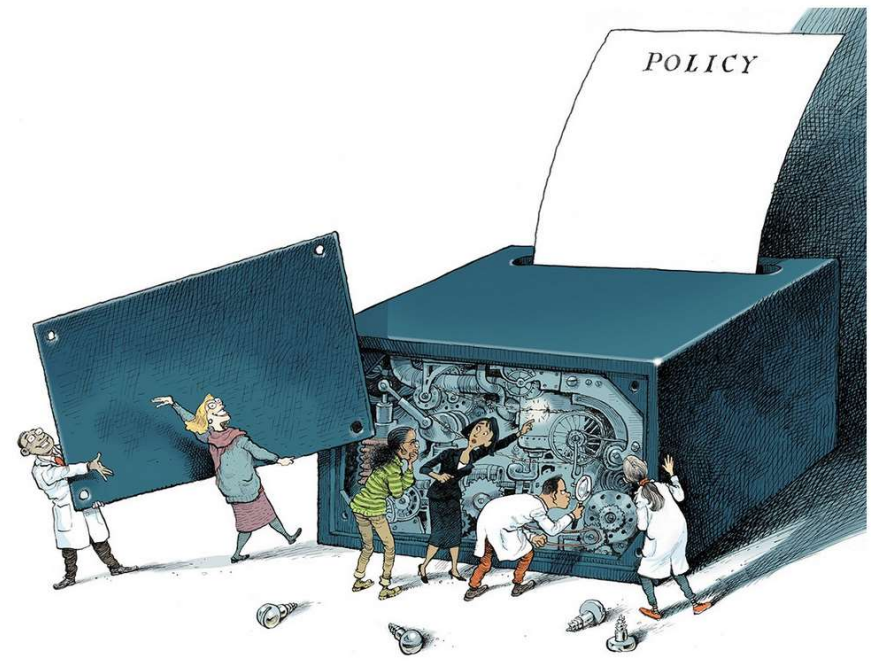
Quantification can backfire.

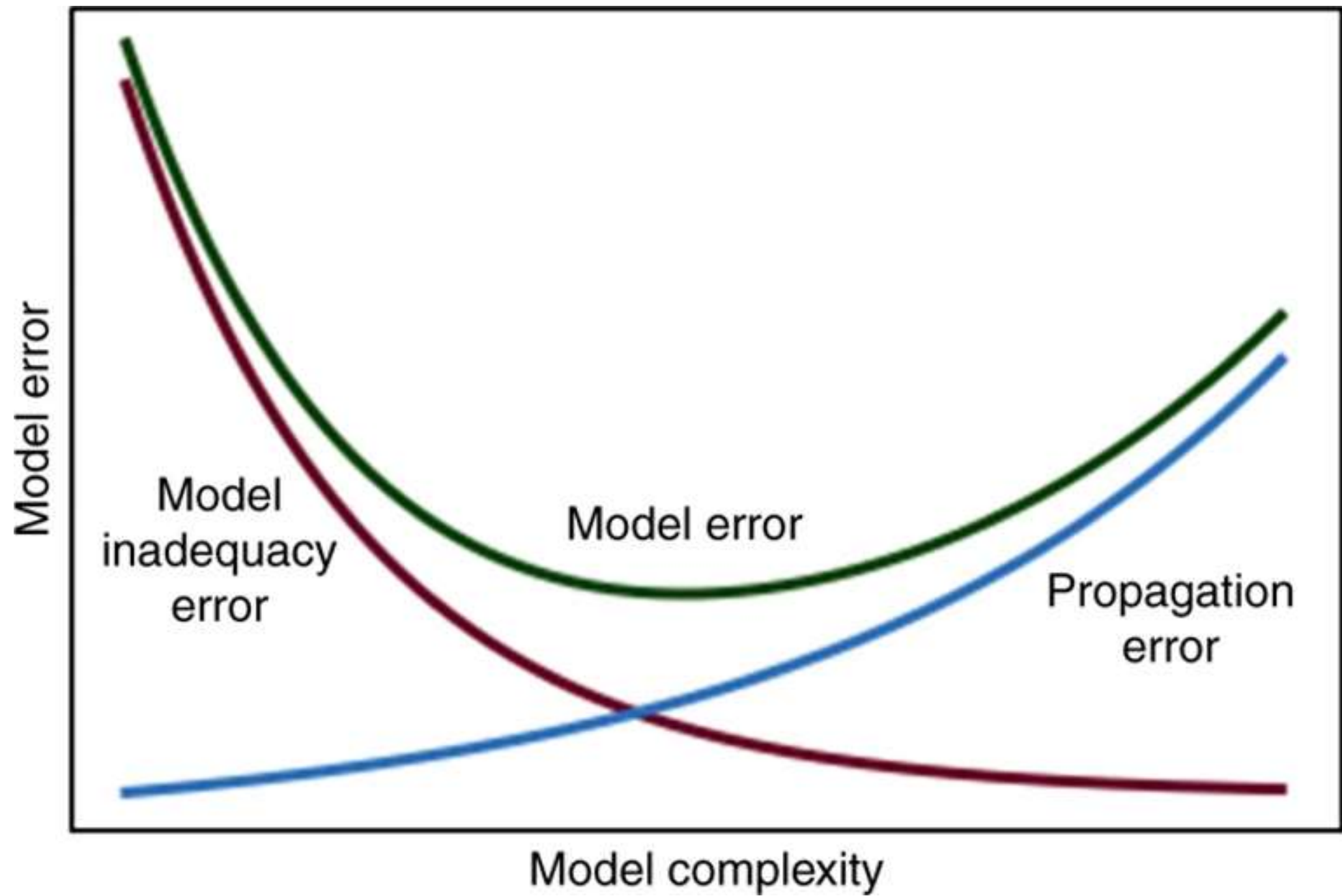**Mind the unknowns**

Acknowledge ignorance

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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

1. Additional information and references   >260 references

Model error vs. Model complexity, showing Model inadequacy error (decreasing), Propagation error (increasing), and the combined Model error curve with a minimum.

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Complexity can be the enemy of relevance
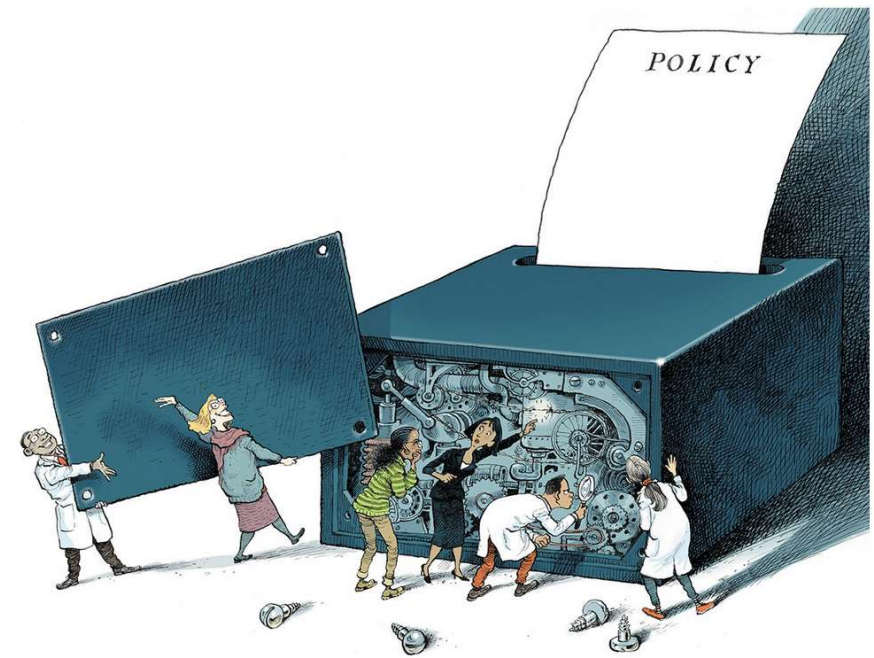
→ ## Mind the framing

Match purpose and context
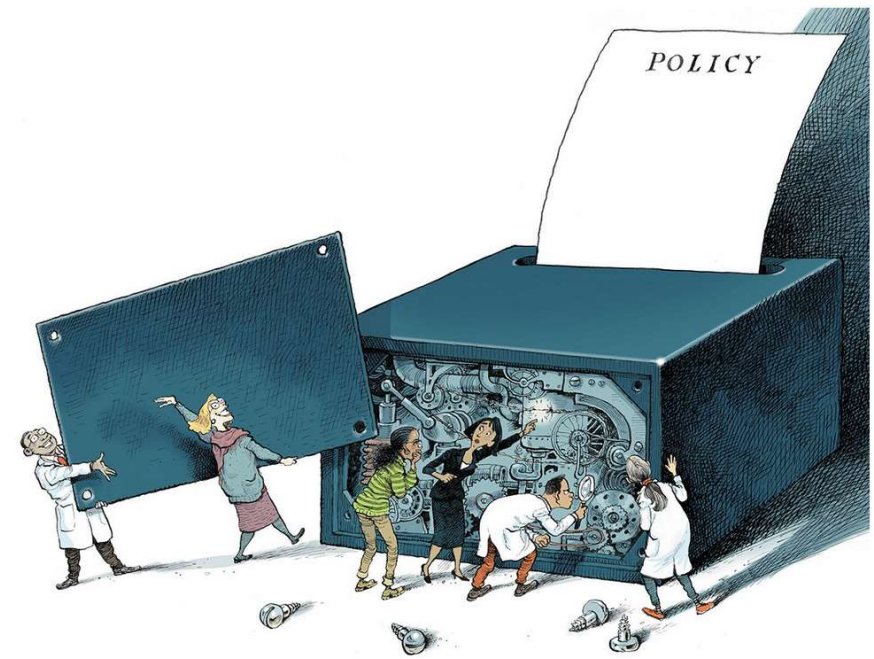
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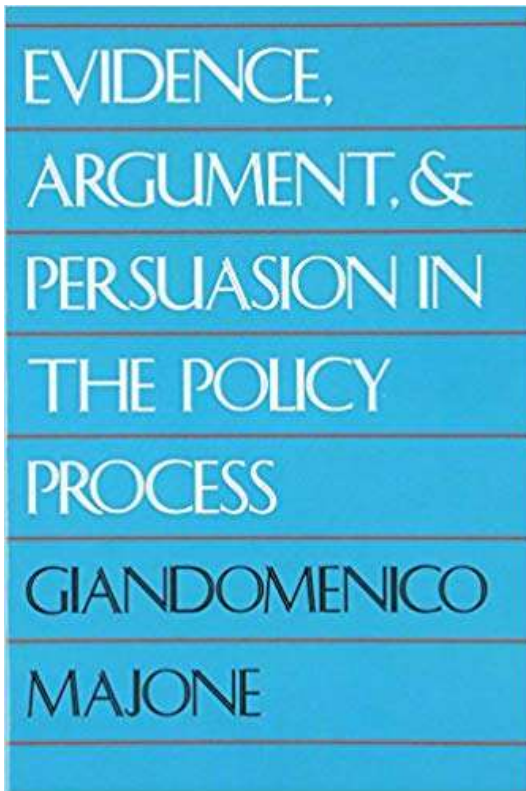··· models will reflect the interests, disciplinary orientations and biases of the developers···

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

Ulrich Beck (1944 –2015)

EVIDENCE, ARGUMENT, & PERSUASION IN THE POLICY PROCESS

GIANDOMENICO MAJONE

1989

Ulrich Beck

Risk Society
Towards a New Modernity

1992 (1986)

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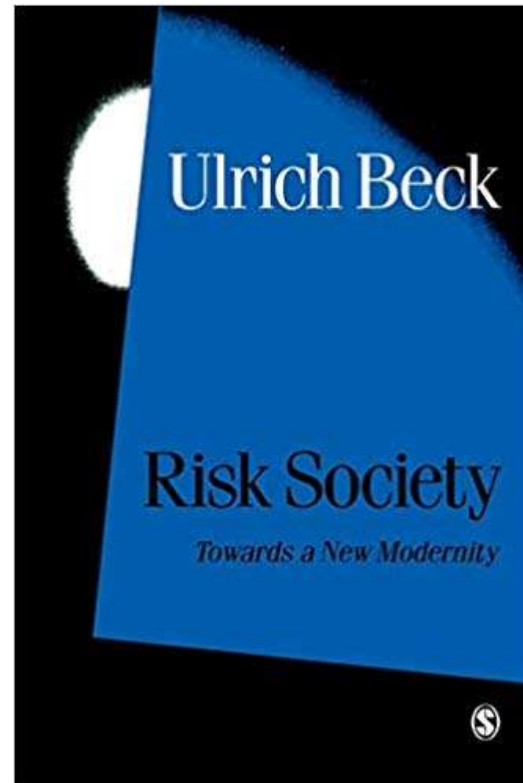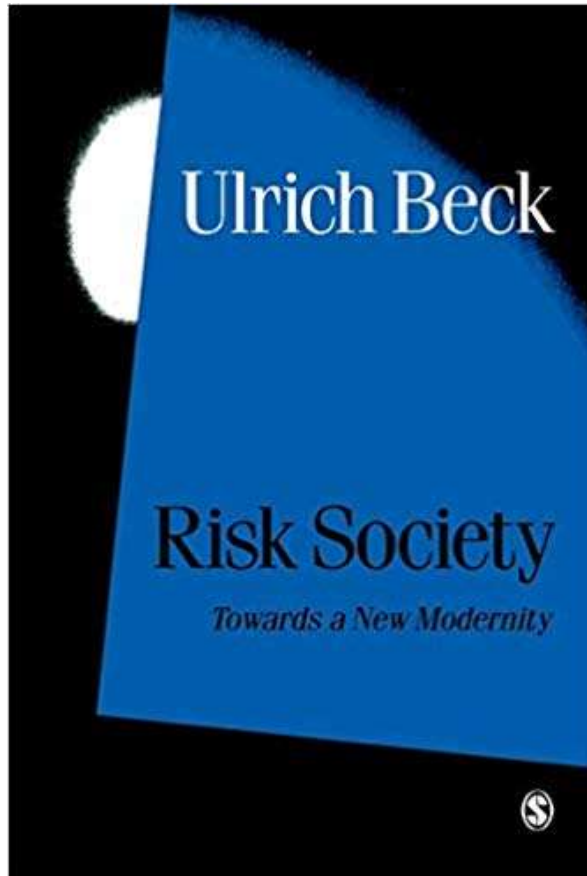
Environmental Science & Policy
Volume 106, April 2020, Pages 87-98

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."

Risk Society
Towards a New Modernity

Ulrich Beck

1992 (1986)

Ulrich Beck
(1944 –2015)

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]

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

Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

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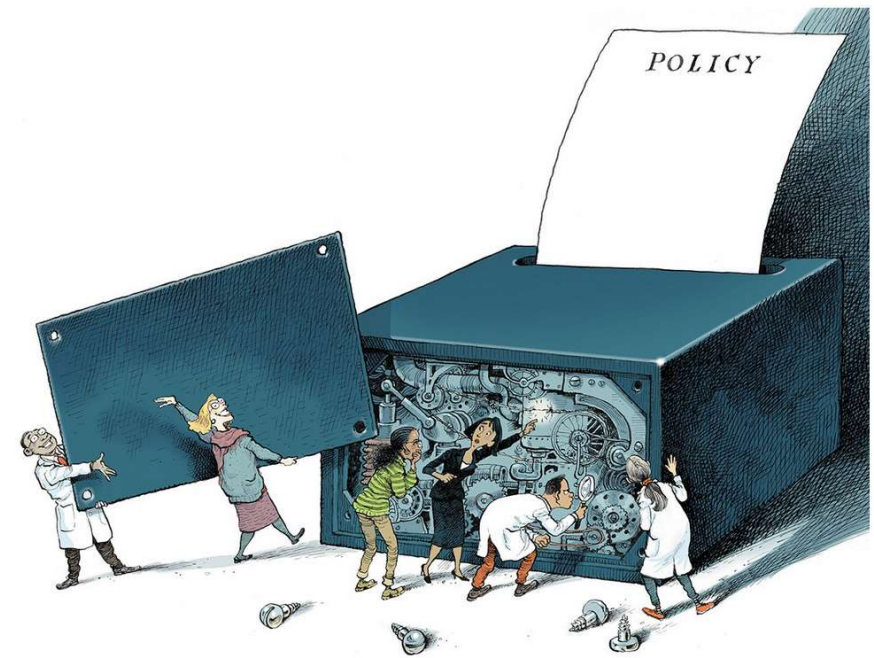
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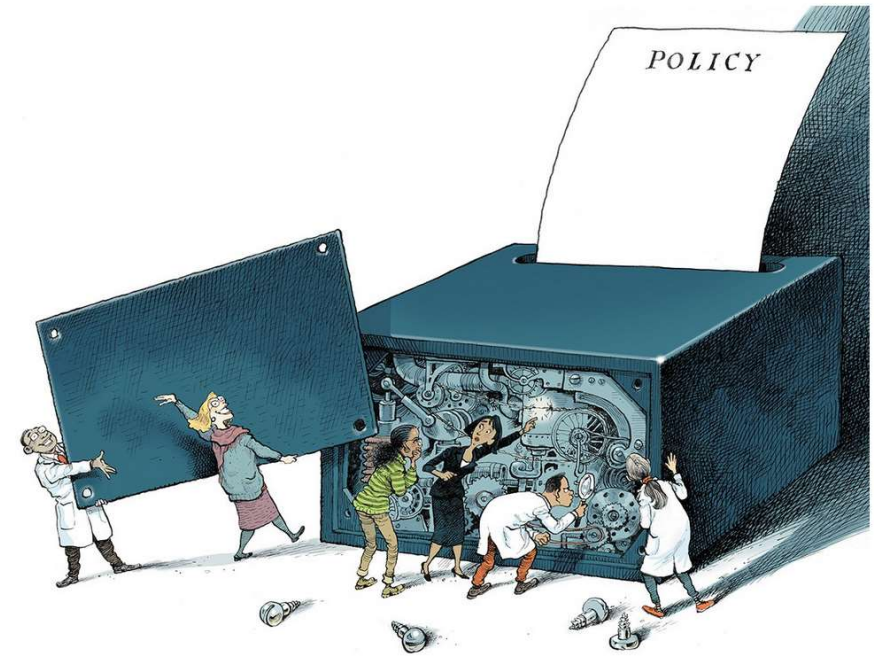
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<< Back to Article
WIRED MAGAZINE: 17.03
Recipe for Disaster: The Formula That Killed Wall Street
By Felix Salmon   02.23.09

$$\Pr[T_A < 1, T_B < 1] = \phi_2(\phi^{-1}(F_A(1)), \phi^{-1}(F_B(1)), \gamma)$$

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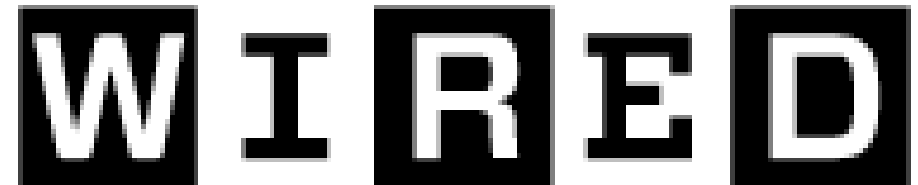
Source: https://www.wired.com/2009/02/wp-quant/

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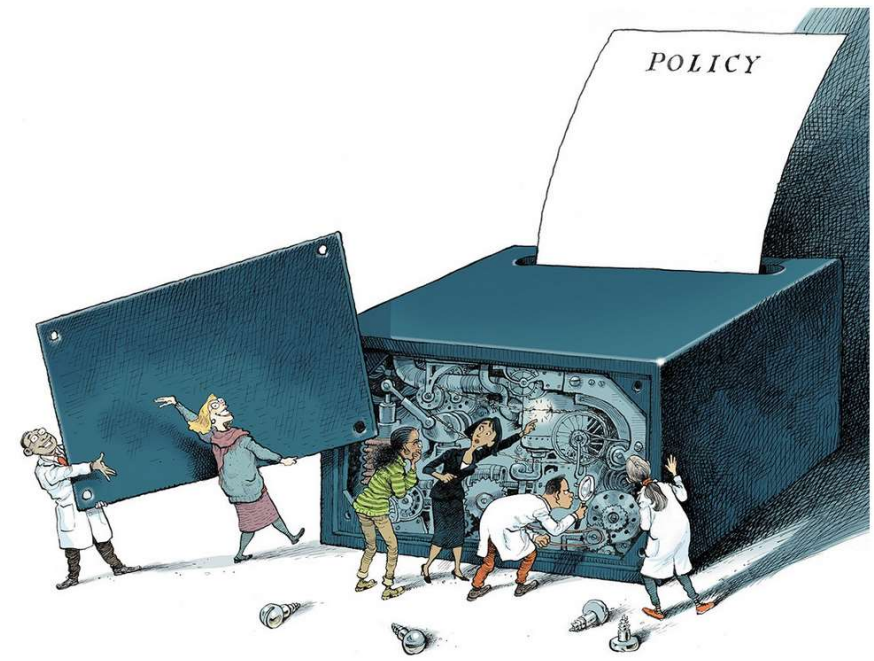
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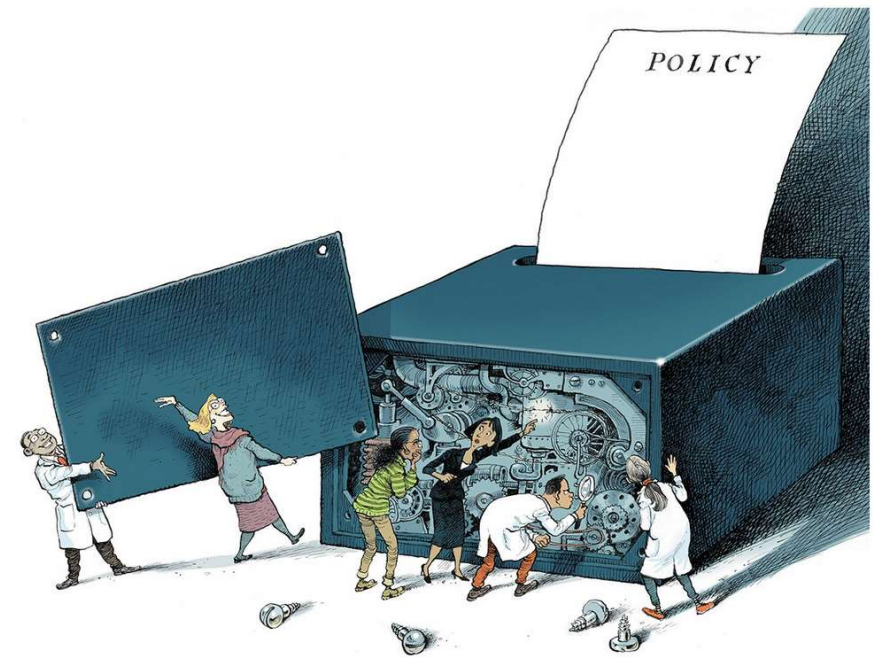## Mind the consequences

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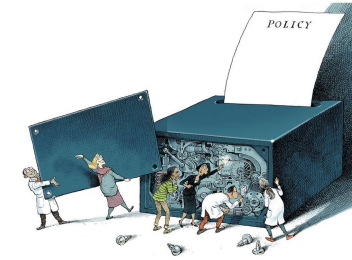
Acknowledge ignorance

Mind the unknowns

Acknowledge ignorance

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__Other
s_Testify_on_Coronavirus_Response_Part_1
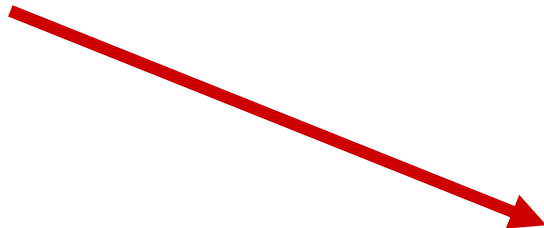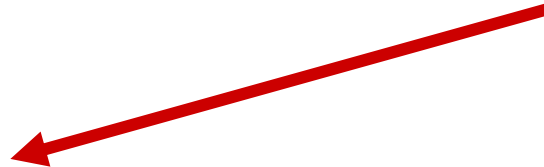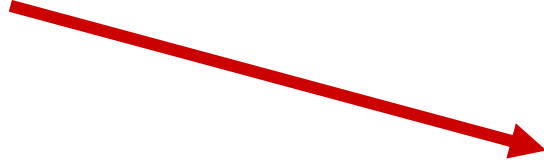
Reproducibility

is a necessary
condition for

Transparency

is a necessary
condition for

Legitimacy

is a necessary
condition for

Epistemic authority

Sensitivity auditing

EC impact assessment guidelines: sensitivity analysis & auditing

European Commission. November 2021. "Better Regulation: Guidelines and Toolbox."
https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

Better Regulation TOOLBOX

November 2021

Sensitivity auditing in the EC Guidelines (p. 563)

"Sensitivity auditing is a wider consideration of the effect of all types of uncertainty, including structural assumptions embedded in the model, and subjective decisions taken in the framing of the problem."

European Commission

Better Regulation
TOOLBOX

November 2021

Sensitivity auditing in the EC Guidelines (p. 563)

"In general, sensitivity auditing stresses the idea of clearly communicating the extent to which particular models can be used to support policy decisions and their results can be trusted, taking into account as much as possible all forms of potential uncertainty, …"

Sensitivity auditing in the EC Guidelines (p. 563)

"… and to anticipate criticism by third parties. In particular, one should avoid giving the impression of false confidence by 'quantification at all costs'."

Sensitivity auditing in the EC Guidelines (p. 563)

"In some cases there is simply not enough data, or the process is too complex, to give a meaningful quantitative prediction."

Better Regulation
TOOLBOX

November 2021

Sensitivity Auditing

What do I make of your latinorum? Sensitivity auditing of mathematical modelling

Saltelli, A., Guimarães Pereira, Â.,
Van der Sluijs, J.P. and Funtowicz, S.

Ângela Guimarães Pereira

The rules of sensitivity auditing

1. Check against rhetorical use of mathematical modelling;
2. Adopt an "assumption hunting" attitude; focus on unearthing possibly implicit assumptions;
3. Check if uncertainty been instrumentally inflated or deflated.

4. Find sensitive assumptions before these find you; do your SA before publishing;

5. Aim for transparency; Show all the data;

6. Do the right sums, not just the sums right;

7. Perform a proper global sensitivity analysis.

The End

@andreasaltelli