Models: a state of exception

Andrea Saltelli

Inaugural Lecture @UNIFI – DISEI
Florence, December 12, 2023

upf. BARCELONA SCHOOL OF MANAGEMENT

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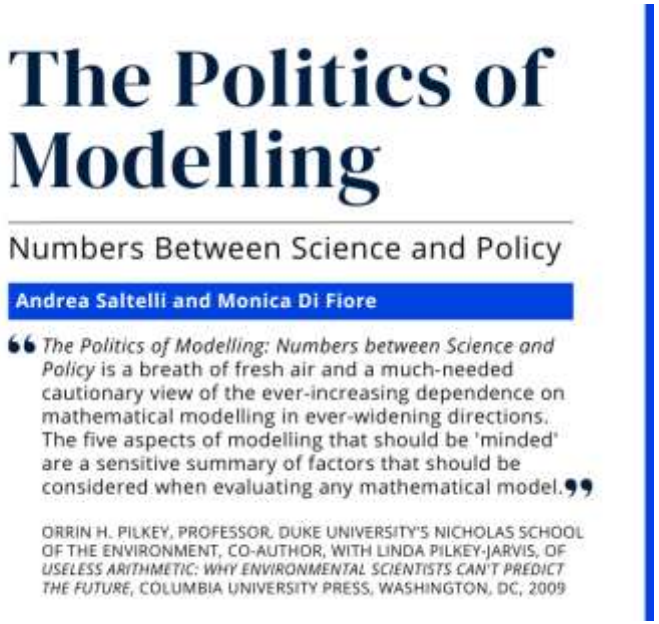

Where to find this talk: www.andreasaltelli.eu

Andrea Saltelli

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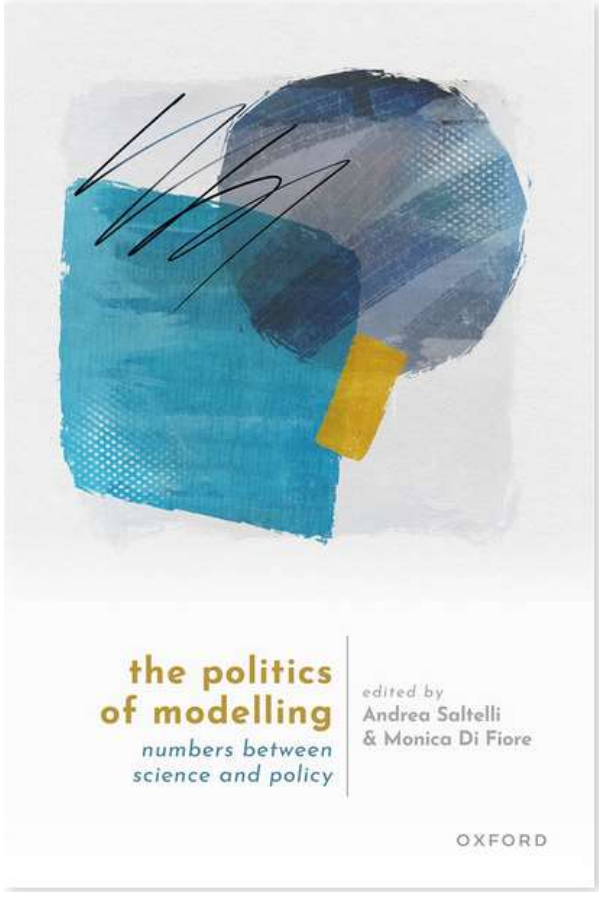
August 25 2023: The politics of modelling is out!



Praise for the volume

"A long awaited examination of the role —and obligation —of modeling."
Nassim Nicholas Taleb , Distinguished Professor of Risk Engineering, NYU Tandon School of Engineering. Author, of the 5 -volume series Incerto.

***

"A breath of fresh air and a much needed cautionary view of the ever-widening dependence on mathematical modeling."
Orrin H. Pilkey, Professor at Duke University's Nicholas School of the Environment, co-author with Linda Pilkey-Jarvis of Useless Arithmetic: Why Environmental Scientists Can't Predict the Future, Columbia University Press 2009.

***

"The methods by which power insinuates itself

Mastodon Toots by
@AndreaSaltelli

AndreaSaltelli
2023/8/28 11:24
August 26 Podcast (16m) - interview for ABC NET RADIO, AUS: Assumptions and consequences: the politics of modelling, Guests: Ehsan Nabavi and Andrea Saltelli, Producer - Chris Bullock.

abc.net.au/listen/programs/sun

View on mstdn.social

Do we live immersed in fantastic numbers?

OPINION

PETER COY

‘The Most Important Number You’ve Never Heard Of’

Sept. 17, 2021

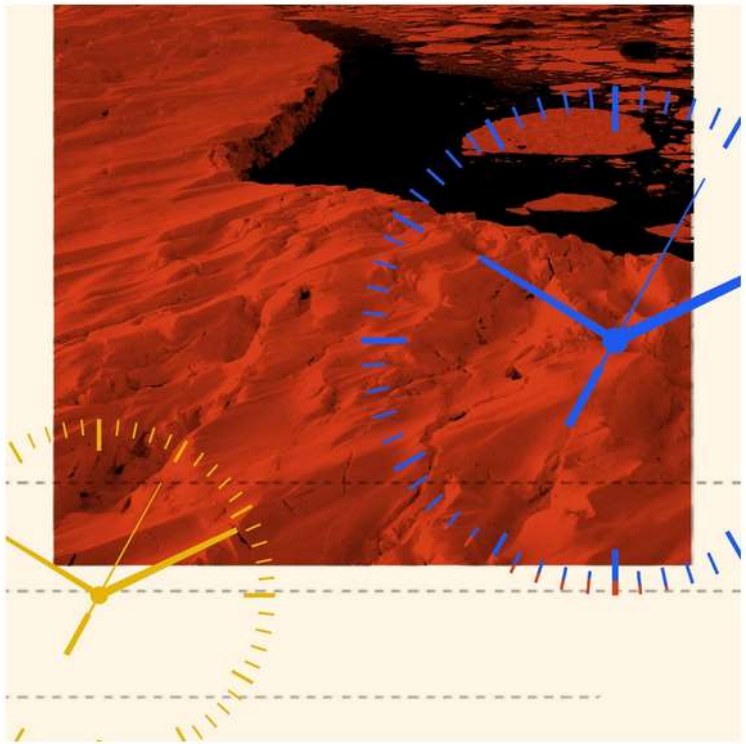


Illustration by Arsh Raziuddin, The New York Times

“social cost of carbon:

=$56 a ton on average at a 3 percent discount rate

=$171 a ton on average at a 2 percent discount rate”

The New York Times

nature climate change

Article

https://doi.org/10.1038/s41558-023-01680-x

Social cost of carbon estimates have increased over time

Richard S. J. Tol

Received: 3 August 2022

Accepted: 23 April 2023

Published online: 15 May 2023

Check for updates

Mathematical models predicting the damage in dollars from hurricanes and draughts up to the year 2300

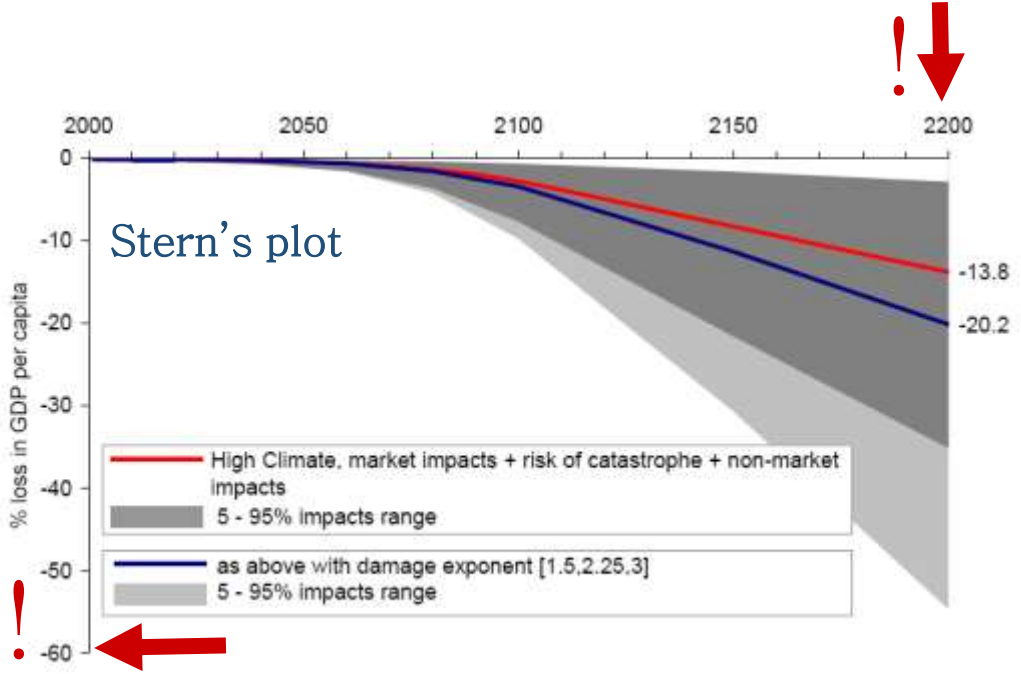
RESOURCES *for the* FUTURE

The Social Cost of Carbon: Advances in Long-Term Probabilistic Projections of Population, GDP, Emissions, and Discount Rates

Kevin Rennert, Brian C. Prest, William A. Pizer, Richard G. Newell, David Anthoff, Cora Kingdon, Lisa Rennels, Roger Cooke, Adrian E. Raftery, Hana Ševčíková, and Frank Errickson

Working Paper 21-28
October 2021

The Stern-Nordhaus controversy; a reverse engineering the model: ➔ uncertainty is too large to take decisions ➔ both Stern and Nordhaus are wrong



Global Environmental Change 20 (2010) 298–302

Contents lists available at ScienceDirect

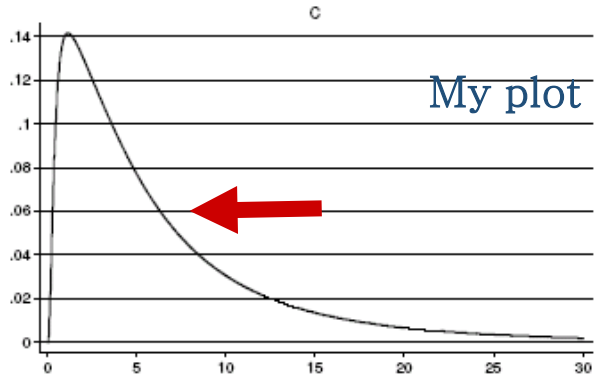
Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Sensitivity analysis didn't help. A practitioner's critique of the Stern review

Andrea Saltelli *, Beatrice D'Hombres

Joint Research Centre, Institute for the Protection and Security of the Citizen, Ispra, Italy



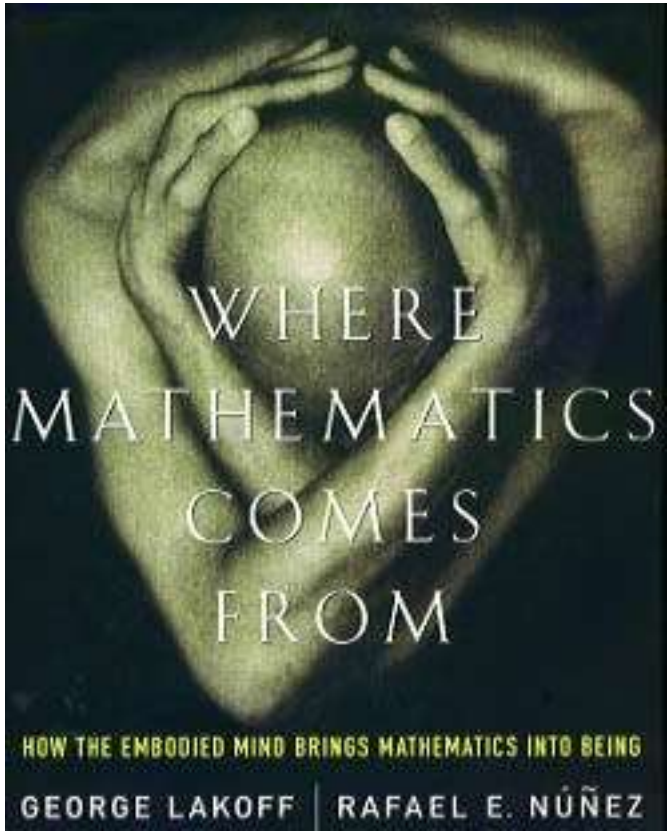
Why models live in a state of exception

Unparalleled palette of methods / epistemic authority / invisible models

Models dispose of a unique repertoire of methods.

Are endowed with unparallel epistemic authority that originates from mathematics, the highest ranked among scientific disciplines (Davies & Hersh, 1986), considered by the fathers of the scientific revolution the language of God himself, up to the point that reconnecting it to human experience is up today an unfinished project (Lakoff & Núñez, 2001).

Lack of agreed standards. Modelling as art/craft (Rosen).



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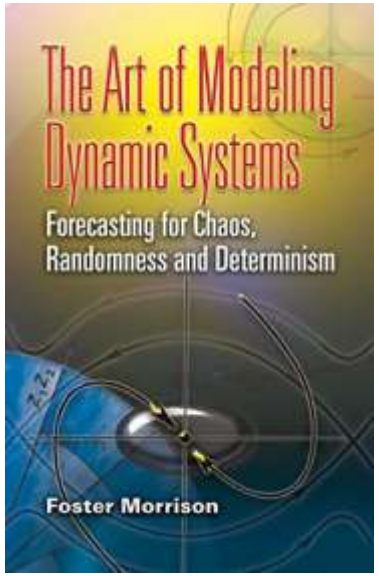
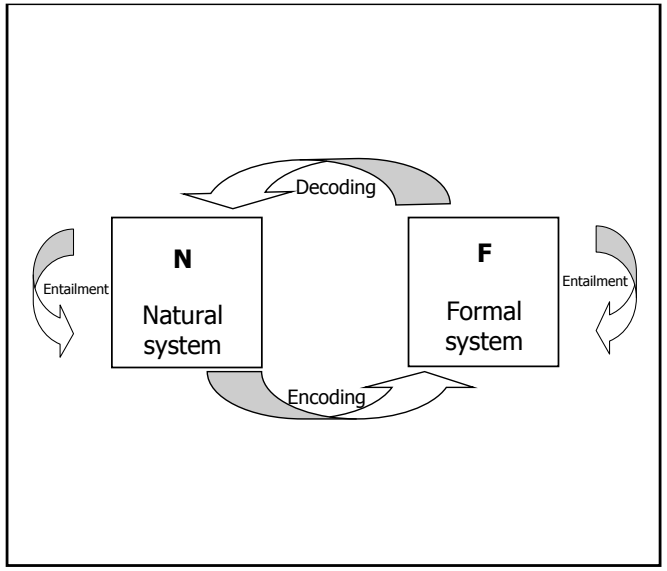
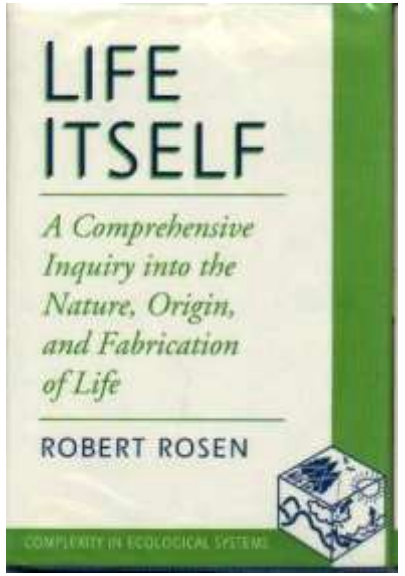
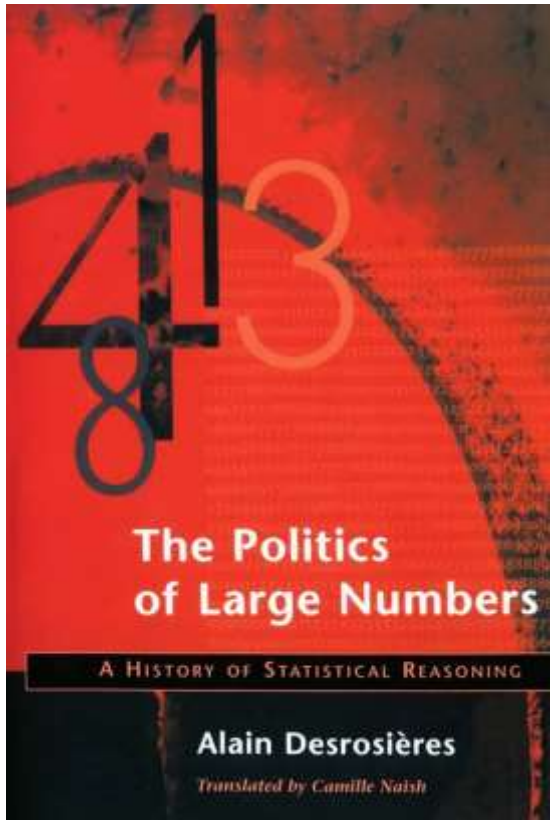






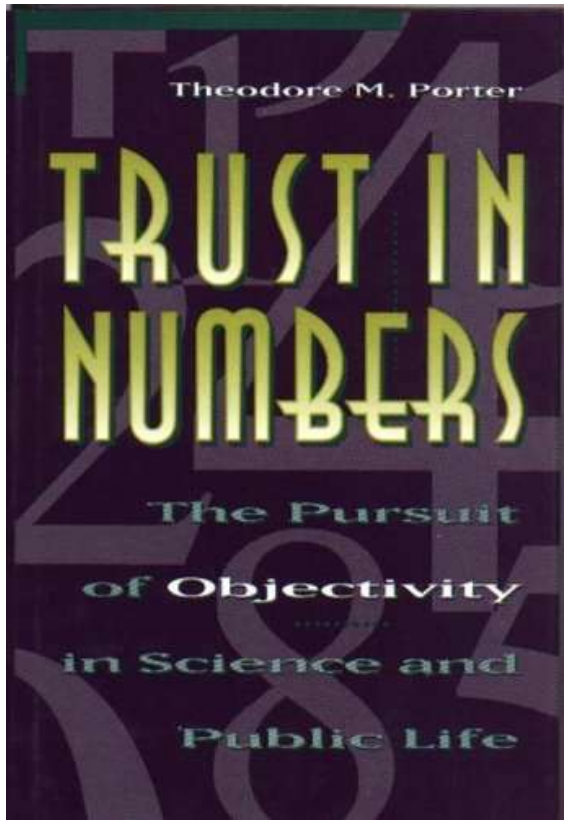
Louie, A.H. 2010. “Robert Rosen’s Anticipatory Systems.” Foresight 12 (3): 18–29.
Padilla, J. J., Diallo, S. Y., Lynch, C. J., & Gore, R. (2018). Observations on the practice and profession of modeling and simulation: A survey approach. SIMULATION, 94(6), 493–506.

Why models live in a state of exception



Mathematical models escape sociology of quantification

Statistics has a much deeper connection to sociology, and to sociology of quantification in particular (Desrosières, 1998; Mennicken & Espeland, 2019; Mennicken & Salais, 2022) than mathematical modelling. Sociology of quantification treats impact assessment tools such as cost benefit analysis (Porter, 1995). Little on modelling, see an exception in (Morgan & Morrison, 1999).



Why models live in a state of exception

Mathematical models escape sociology of quantification

Article | Open access | Published: 06 May 2023

What can mathematical modelling contribute to a sociology of quantification?

Andrea Saltelli & Arnald Puy

Humanities and Social Sciences Communications **10**, Article number: 213 (2023) | Cite this article

1356 Accesses | **1** Citations | **4** Altmetric | Metrics

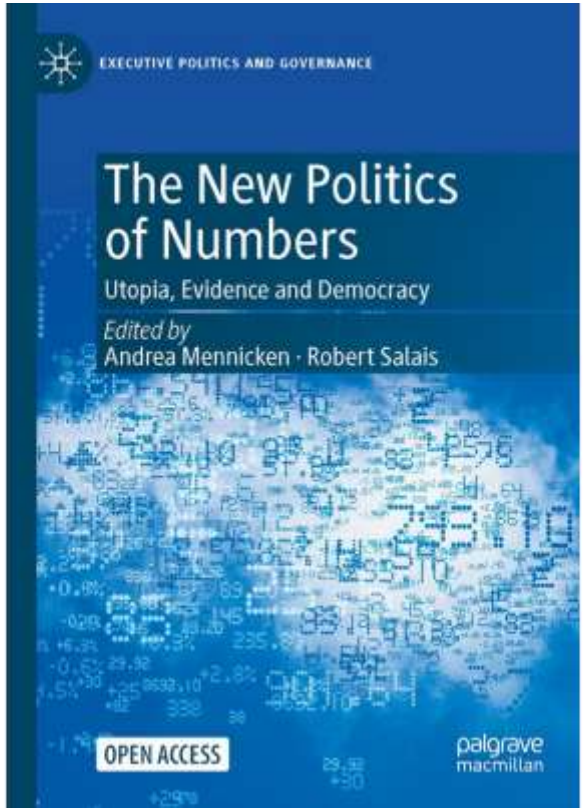
We suggest that methodological adequacy can be upheld by techniques in the field of sensitivity analysis, while normative adequacy and fairness are targeted by the different dimensions of sensitivity auditing

Why models live in a state of exception

Model have a better pretense to neutrality than other instances of quantification

There is a Technical Quality and there is a Normative quality. Since the technique is never neutral a technical proof of quality is illusory without a parallel investigation of normative quality (Amartya Sen; Robert Salais).

How the numbers of neoliberalism (New Public Management) constitute a regime of a-democracy; the example of indicators of employment



Salais, R. (2022). "La donnée n'est pas un donné": Statistics, Quantification and Democratic Choice.

Why models live in a state of exception

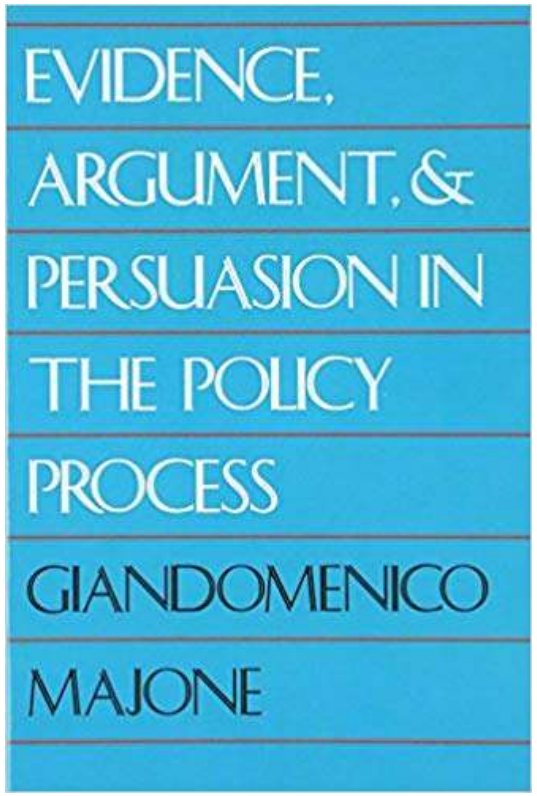
Mathematical models are extremely malleable

Models lend themselves very naturally to evidence based policy. In statistics you have to reverse the statistical pyramid to achieve the same result – this goes much faster with models

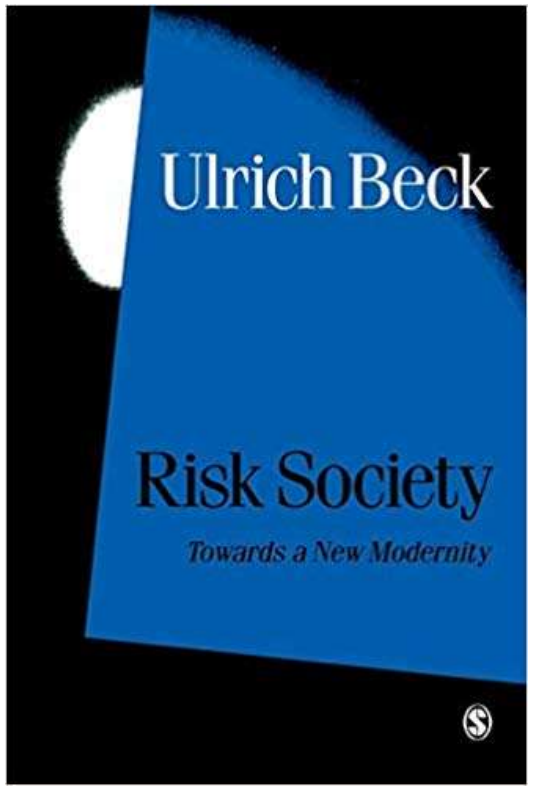
Evidence based policy	**Statistics (creating things that hold together for the solution of practical problems)**
Policy based evidence	Governance driven quantification (a reversal of the statistical pyramid)

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

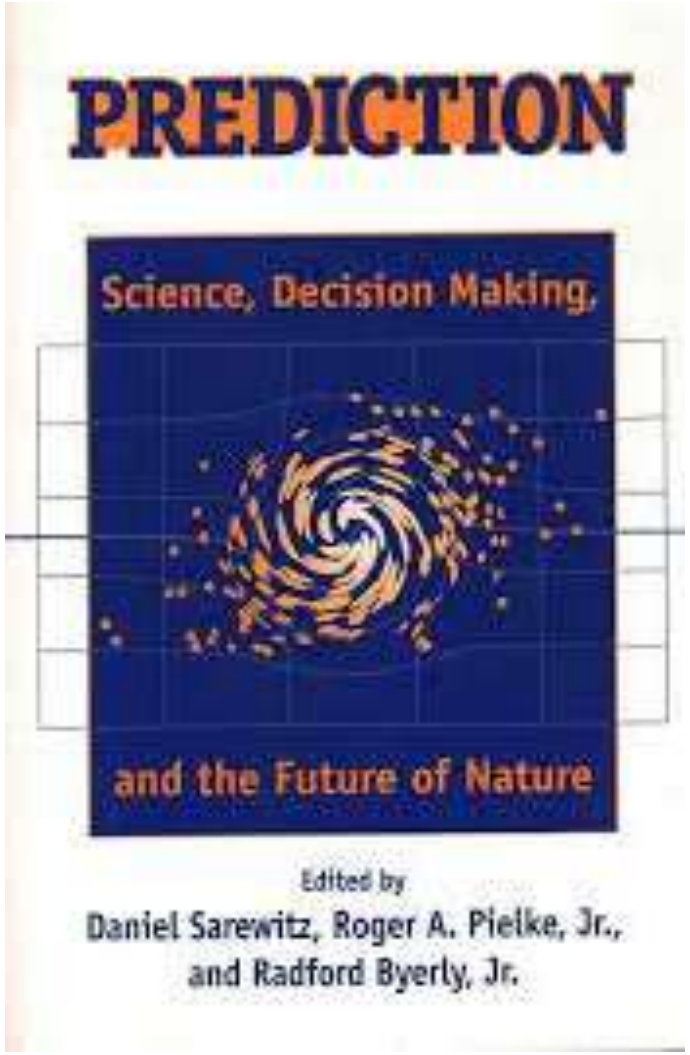
Andrea Saltelli [a, b], Lorenzo Benini [c], Silvio Funtowicz [a], Mario Giampietro [d, e], Matthias Kaiser [a], Erik Reinert [a, f], Jeroen P. van der Sluijs [a, g, h]

Why models live in a state of exception

Models cannot be falsified

Models do not meet classic (Popperian) criteria of scientificity. Oreskes (2000) has observed that model-based predictions tend to be treated like logical inferences in a classic hypothetic-deductive model.

The relation between models and data is often more symbiotic than adversarial. In climate studies this relation has been defined as 'incestuous', exactly to make the point that in modelling studies using data to prove a model wrong may not be straightforward (Edwards, 1999).

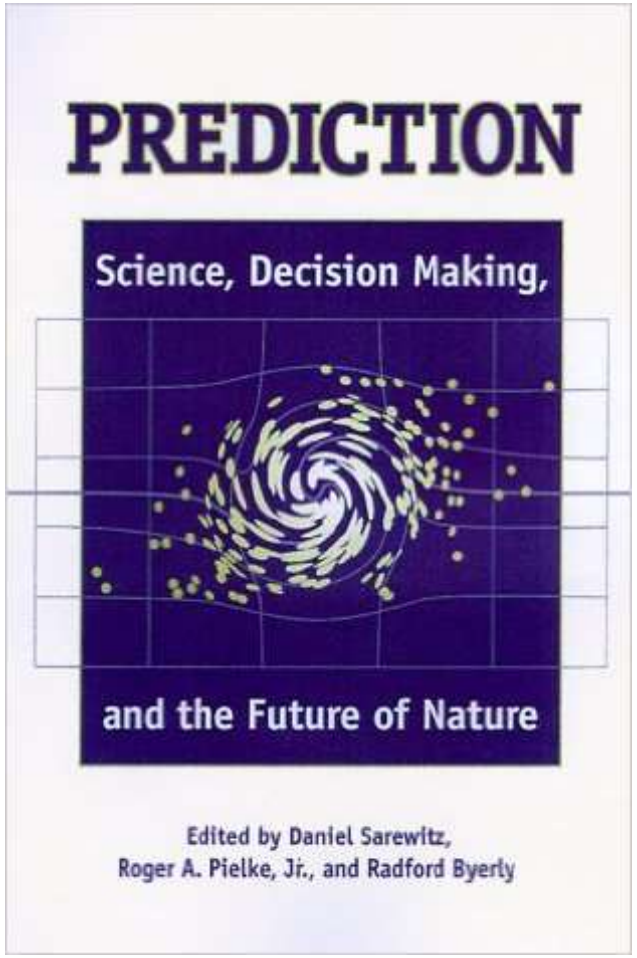


“models are most useful when they are used to challenge existing formulations, rather than to validate or verify them”

Naomi Oreskes

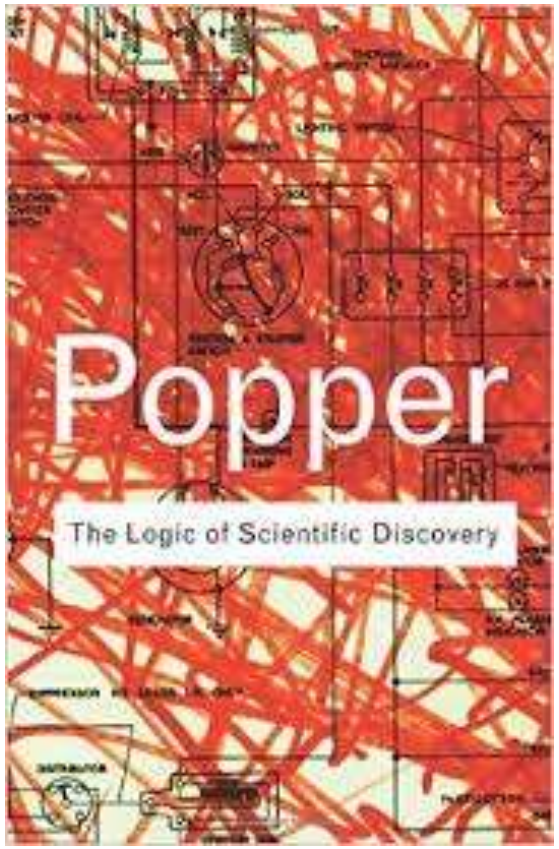
N. Oreskes, K. Shrader-Frechette, and K. Belitz, “Verification, Validation, and Confirmation of Numerical Models in the Earth Sciences,” Science, 263, no. 5147, 1994.

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)



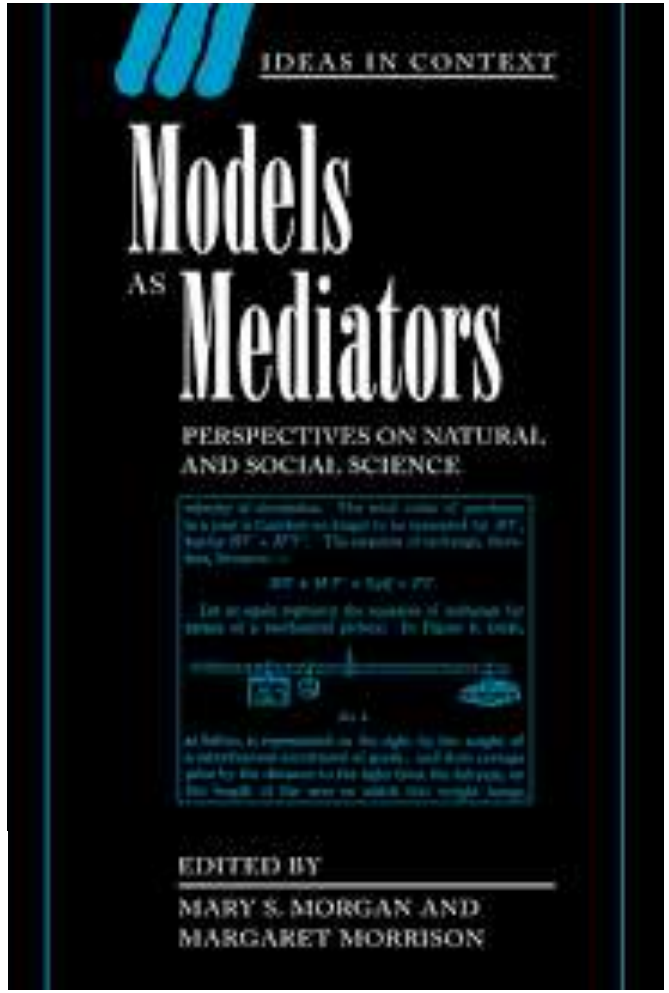
“When a model generates a prediction, of what precisely is the prediction a test? The laws? The input data? The conceptualization?

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

Why models live in a state of exception

Models as the most effective mediators between theory and reality

Due to their independence from both theory and the world, models act as "mediators", instruments that advance understanding thanks to the tacit craftsmanship of scientists (Morgan & Morrison 1999). They are metaphors that express "in an indirect form our presuppositions about the problem and its possible solutions", and can thus assist in an **extended community of peers** to deliberate about social or ecological problems (Ravetz 2023).



Extended peer community

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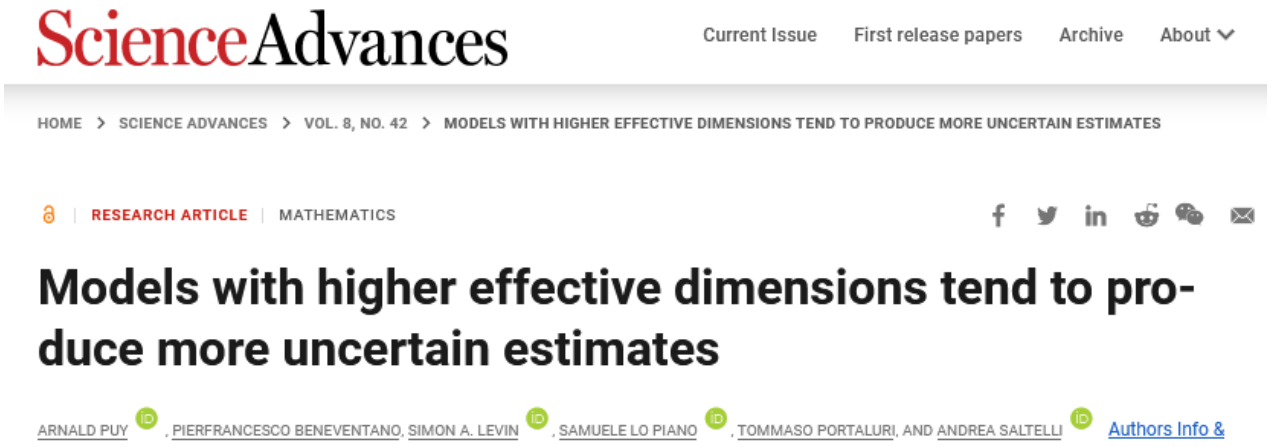
From Wikipedia, the free encyclopedia

The concept of **Extended peer community** belongs to the field of Sociology of science, and in particular the use of science in the solution of social, political or ecological problems. It was first introduced by in the 1990s by Silvio Funtowicz and Jerome R. Ravetz.[1] in the context of what would become Post-normal science. An **Extended peer community** is intended by these authors as a space where both credentialed experts from different disciplines and lay stakeholders can discuss and deliberate.

Consequences descending from state of exception

Gross asymmetry developers/ users

Models operate in a context of asymmetry of knowledge between developers and users (Jakeman *et al.*, 2006). There are ‘black boxes’ also in other families of quantification, typically algorithms or statistics. Yet this asymmetry may be larger for mathematical models (Puy et al., 2022).



Consequences descending from state of exception

Ritual use

An important analogy between statistical and mathematical modelling is in the ‘ritual’ use of methods. Rituals in statistics are described in Gigerenzer (Gigerenzer, 2018; Gigerenzer & Marewski, 2015). For models here an anecdote by Kenneth Arrow: producing one month-ahead weather forecasts

“… The commanding general is well aware that the forecasts are no good. However, he needs them for planning purposes”

See also Niklas Luhmann ‘deparadoxification’ (Moeller, 2006); See also politicians’ claim: ‘We follow the science’ during COVID-19

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.

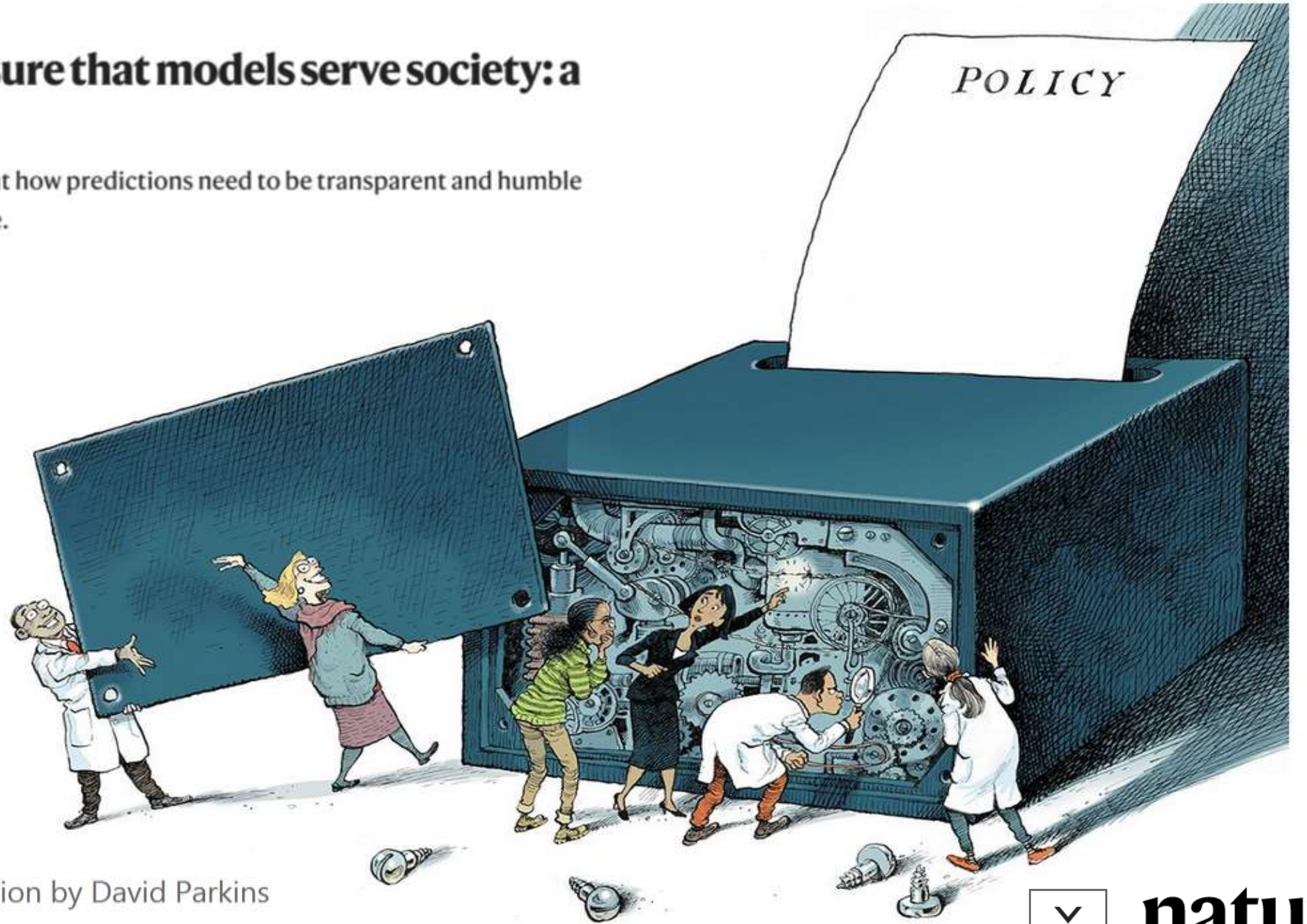
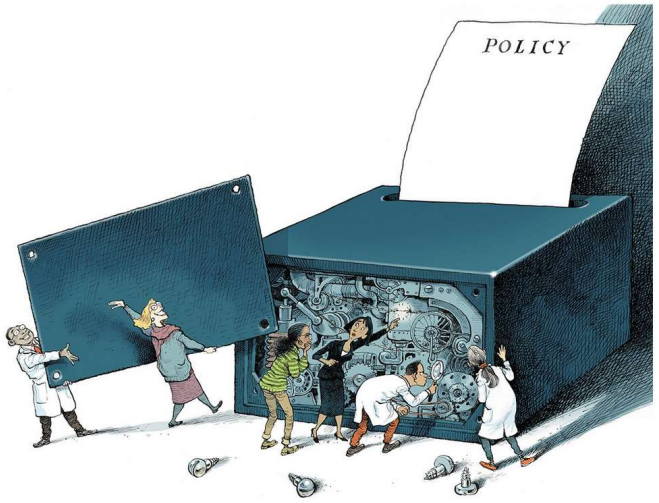


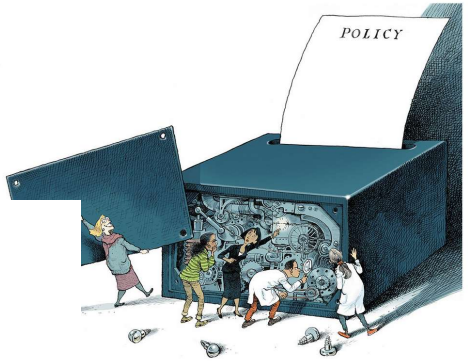
Illustration by David Parkins

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

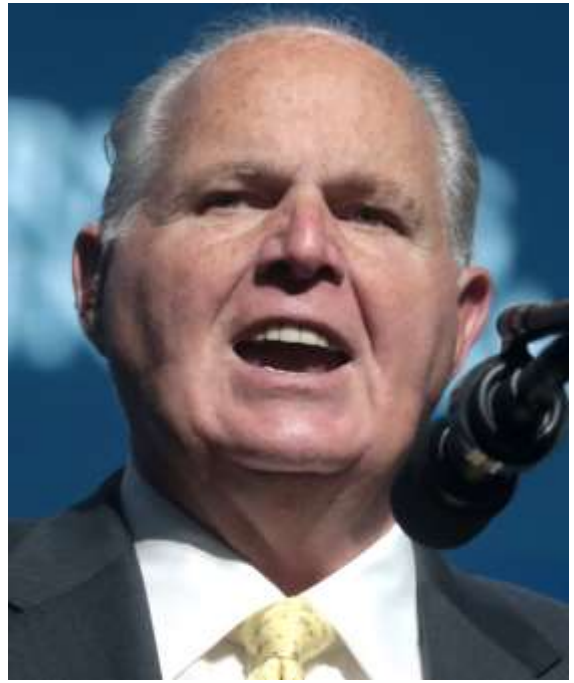
It wasn't so much the numbers themselves, frightening though they were, as who reported them: Imperial College London.

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

Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

Complexity can be the enemy of relevance

Mind the framing

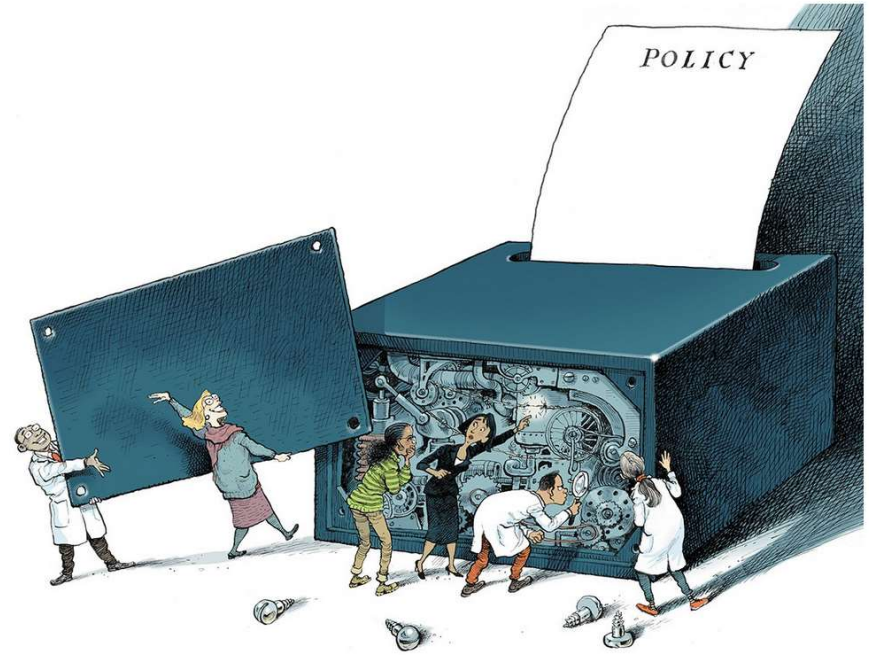
Match purpose and context

Mind the consequences

Quantification can backfire

Mind the unknowns

Acknowledge ignorance



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Acknowledge ignorance

Consequences descending from state of exception

Models and trans-science

Models lend themselves to trans-science (Weinberg, 1972).

- How many people will drive autonomous cars by 2050.
- How will the spread of malaria change if global temperature increases by 1.5ºC.
- What will be the cost of CO2 averaged over the next three centuries

Model as Borges' (1946) one-to-one map of the empire

comment | Check for updates

A digital twin of Earth for the green transition

For its green transition, the EU plans to fund the development of digital twins of Earth. For these twins to be more than big data atlases, they must create a qualitatively new Earth system simulation and observation capability using a methodological framework responsible for exceptional advances in numerical weather prediction.

Peter Bauer, Bjorn Stevens and Wilco Hazeleger

The European Union (EU) intends to become climate neutral by 2050, and the set of policies designed to bring about this green transition — the European Green Deal — was announced in December 2019 (ref. [1]). Accompanied by €1 trillion of planned investment, Green Deal policies aim to help the world's second-largest economy sustainably produce energy, develop carbon-neutral fuels and advance circular products in energy-intensive industrial sectors with zero waste and zero pollution.

A key element of the Green Deal is its dependence on the 'digital transformation' — an openly accessible and interoperable European dataspace as a central hub for informed decision making. The EU identified two landmark actions to support the necessary information systems: GreenData4All[2] and Destination Earth[3]. Whereas GreenData4All will develop the European approach to discover, manage and exploit geospatial information, Destination Earth aims to construct highly accurate models, or 'digital twins', of the Earth to monitor and predict environmental change and human impact in support of sustainable development. Aligned with the new Digital Europe funding programme[4], Destination Earth is expected to start in 2021, and the first, high-priority digital twins serving extremes prediction and climate change adaptation will

Credit: Map of Layerace / Freepik

… one-to-one map of the empire

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Review Article | Published: 02 May 2023

Big Data in Earth system science and progress towards a digital twin

Xin Li, Min Feng, Youhua Ran, Yang Su, Feng Liu, Chunlin Huang, Huanfeng Shen, Qing Xiao, Jianbin Su, Shiwei Yuan & Huadong Guo

Nature Reviews Earth & Environment 4, 319–332 (2023) | Cite this article

Cornell University

arXiv > physics > arXiv:2306.11175

Physics > Physics and Society

[Submitted on 19 Jun 2023]

Developing Digital Twins for Earth Systems: Purpose, Requisites, and Benefits

Yuhan Rao, Rob Redmon, Kirstine Dale, Sue E. Haupt, Aaron Hopkinson, Ann Bostrom, Sid Boukabara, Thomas Geenen, David M. Hall, Benjamin D. Smith, Dev Niyogi, V. Ramaswamy, Eric A. Kihn

The accelerated change in our planet due to human activities has led to grand societal challenges including health crises, intensified extreme weather events, food security, environmental injustice, etc. Digital twin systems combined with emerging technologies such as artificial intelligence and edge computing provide opportunities to support planning and decision-making to address these challenges. Digital twins for Earth systems (DT4ESs) are defined as the digital representation of the complex integrated Earth system including both natural processes and human activities. They have the potential to enable a diverse range of users to explore what-if scenarios across spatial and temporal scales to improve our understanding, prediction, mitigation, and adaptation to grand societal challenges. The 4th NOAA AI Workshop convened around 100 members who are developing or interested in participating in the development of DT4ES to discuss a shared community vision and path forward on fostering a future ecosystem of interoperable DT4ES. This paper summarizes the workshop discussions around DT4ES. We first defined the foundational features of a viable digital twins for Earth system that can be used to guide the development of various use cases of DT4ES. Finally, we made practical recommendations for the community on different aspects of collaboration in order to enable a future ecosystem of interoperable DT4ES, including equity-centered use case development, community-driven investigation of interoperability for DT4ES, trust-oriented co-development, and developing a community of practice.

Consequences descending from state of exception

Have the strongest grip in policy

Models have their own political economy - economicism, solutionism, reductionism, transforming of the qualitative into quantitative (Stirling, 2023a, 2023b).

The percentage of non-reproducible studies in the field of clinical medical research could reach 85% (Chalmers and Glasziou, 2009). Nobody can provide a similar figure for mathematical modelling.

‘Navigating the political’ (van Beek *et al.* 2022)

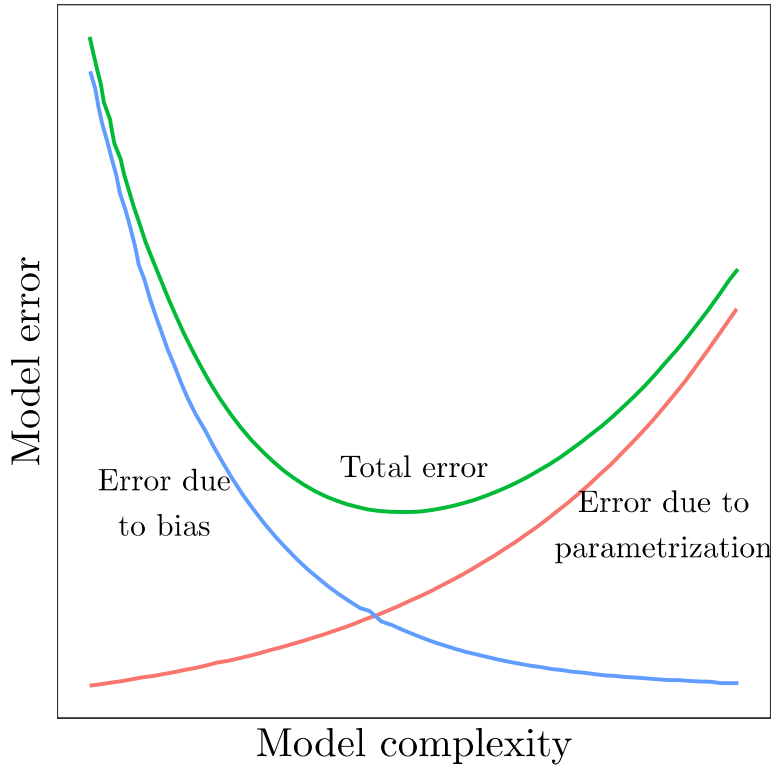
Acting as chameleons, jumping across contexts, Pfleiderer (2020).

Source: National Geographic

Consequences descending from state of exception

Models are vulnerable to modelling hubris

The conjecture of O'Neill (1971), see also Turner & Gardner (2015), posits that too simple a model may miss important features of the system, and thus lead to systematic error, while a too complex one – burdened by an excessive number of estimated parameters, may lead to a greater imprecision due the error propagation.



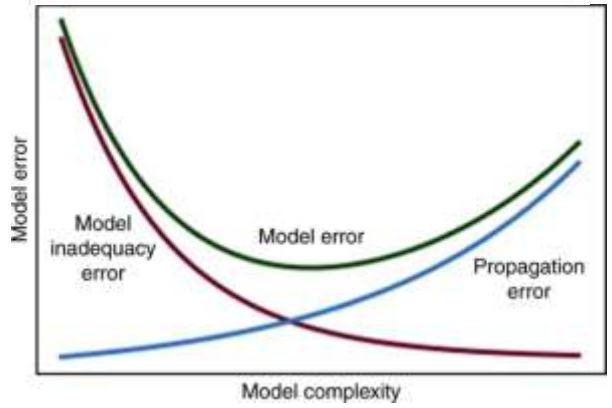
Solutions to resolve the state of exception

Modelling of the modelling process (Sensitivity analysis, sensitivity auditing for de- and re-construction, on the example of statactivism)

➔ retrace what was assumed

➔ check the level of complexity

…



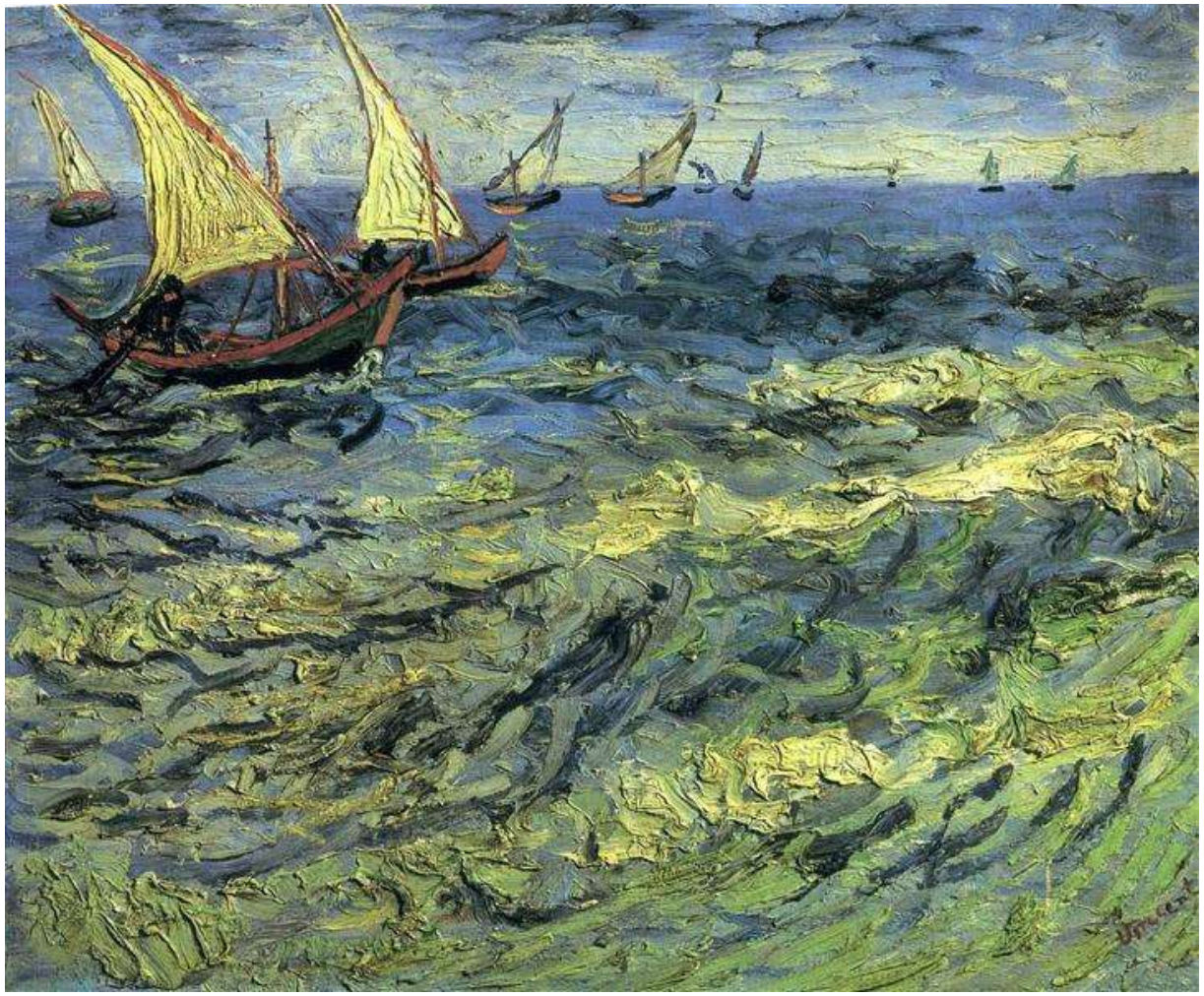
➔check simultaneously technical and normative quality

Example use SA to ascertain that an algorithm does not make implicit use of protected attributes

PROTECTED ATTRIBUTES:

- Age
- Disability
- National Origin
- Race/color
- Religion
- Sex
- (From the US Equal Opportunity Employment Commission)

Why is all this important? Fishing expeditions and 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‡

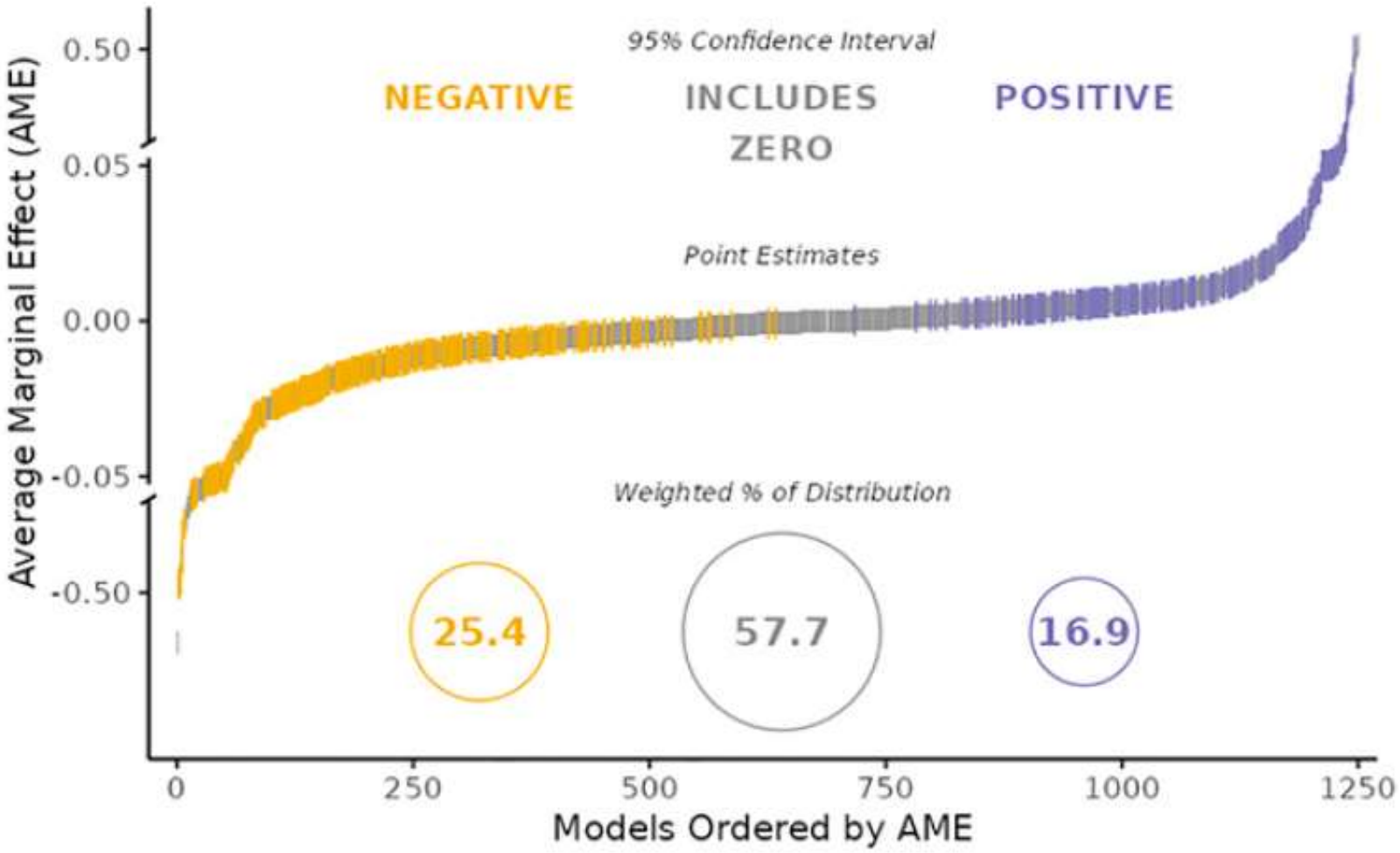
14 Nov 2013

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"
(Breznau et al. 2022)

Solutions to resolve the state of exception

Sensitivity analysis and sensitivity auditing

But the real strength of the models, in my mind at least, were in sensitivity analysis (where one could examine the response of the model to parameters or structures that were not known with precision (i.e., sensitivity analysis), and in the examination of the behavior of the model components relative to that of the real system in question (i.e., validation). By undertaking sensitivity analysis and validation, a great deal can be learned about the real system, including what you do not know. (Hall, 2020)

➔Avoid “quantifying at all costs”, expose ‘funny numbers’

Culture Unbound
Journal of Current Cultural Research

Funny Numbers

By Theodore M. Porter

Solutions to resolve the state of exception

Complexity of interpretation rather than complexity of construction

A finite elements model of an engine, a bridge, or of a human hearth, cannot possibly fall in the category of parsimonious. On the other hand, the simplest of models can lead to an informative and participated debate. Thus was the I=PAT model, whereby the human impact on the environment is driven by population (P) times affluence (A) and technology (T). In the seventies, this model allowed a debate on the limit of growth that continues to the present day (Ehrlich & Holdren, 1971).

Impact of Population Growth: Complacency concerning this component of man's predicament is unjustified and counterproductive.

PAUL R. EHRLICH AND JOHN P. HOLDREN Authors Info & Affiliations

SCIENCE · 26 Mar 1971 · Vol 171, Issue 3977 · pp. 1212-1217 · DOI: 10.1126/science.171.3977.121

Science

Solutions to resolve the state of exception

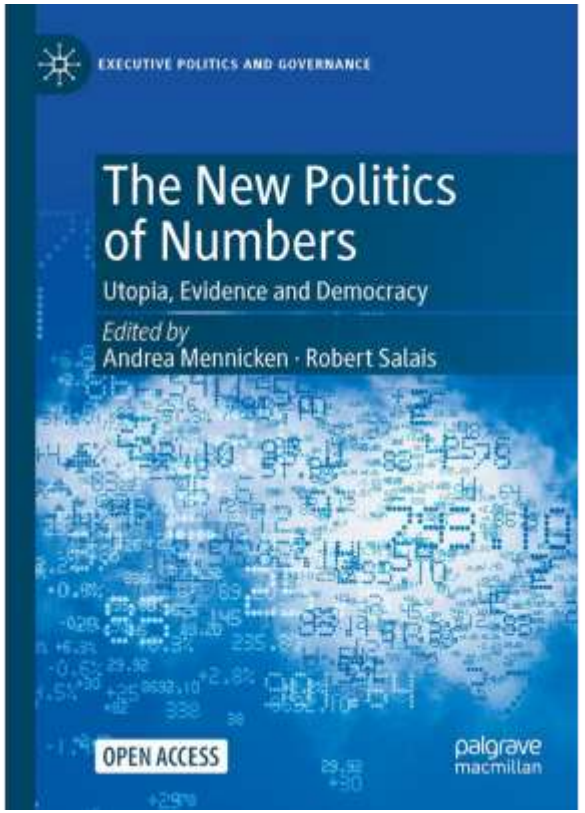
Follow the example of statisticians' Statactivism

When it comes to the quality of their quantifications, few communities have proven as active as that of statisticians. The movement of French Statactivists (Bruno, Didier, & Prévieux, 2014; Bruno, Didier, & Vitale, 2014), in particular, based on a strong national tradition of sociology of quantification (Bourdieu, 1984; Desrosières, 1998), has proven capable to "fight a number with a number" in domain of policy relevance such as poverty (Concialdi, 2014) and consumer prices indices (Samuel, 2022).

Solutions to resolve the state of exception

Follow the example of statisticians' Statactivism

One would very much like to imagine modellers taking the viewpoint of those 'measured' into the analysis as advocated by statactivists (Salais, 2022), making the invisible visible (Bruno, Didier, & Prévieux, 2014), or interiorize in full the double nature – technical and normative, of the quality of a quantification (Mennicken & Salais, 2022)



Solutions to resolve the state of exception

Reciprocal domestication between models and society

The COVID pandemic of 2020 has dramatically increased the visibility of mathematical modelling, accompanied by a considerable level of controversy, either for the deficiencies of the model, or because of disagreement about the policies (Pielke, 2020; Rhodes & Lancaster, 2020). From ‘Flattening the curve’ to … distrust?

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COMMENTARY | Open Access

What did COVID-19 really teach us about science, evidence and society?

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First published: 06 June 2023 | https://doi.org/10.1111/jep.13876

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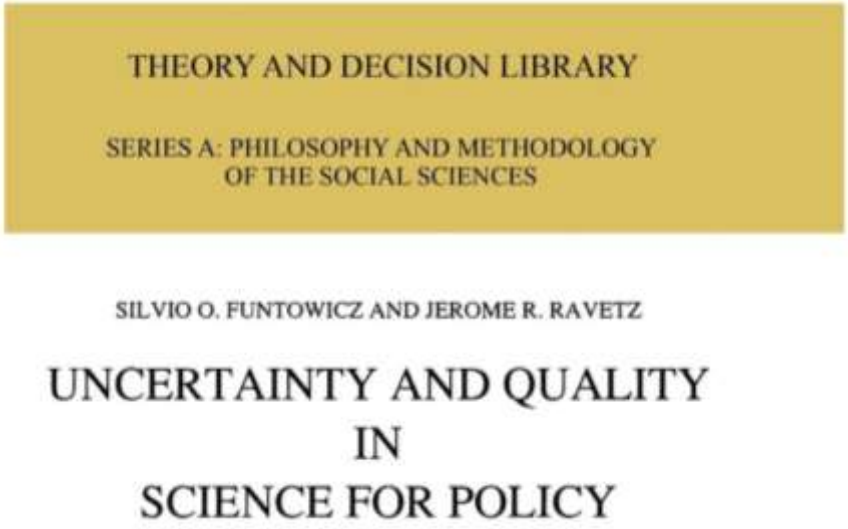
"COVID-19 policies allocated sacrifice, privation and suffering across all walks of society [but] radically different responses from nation to nation—from draconian lockdowns, to relatively permissive and flexible pandemic regimes—made obvious to all that the value of scientific evidence was to support what was politically desirable and possible in different contexts

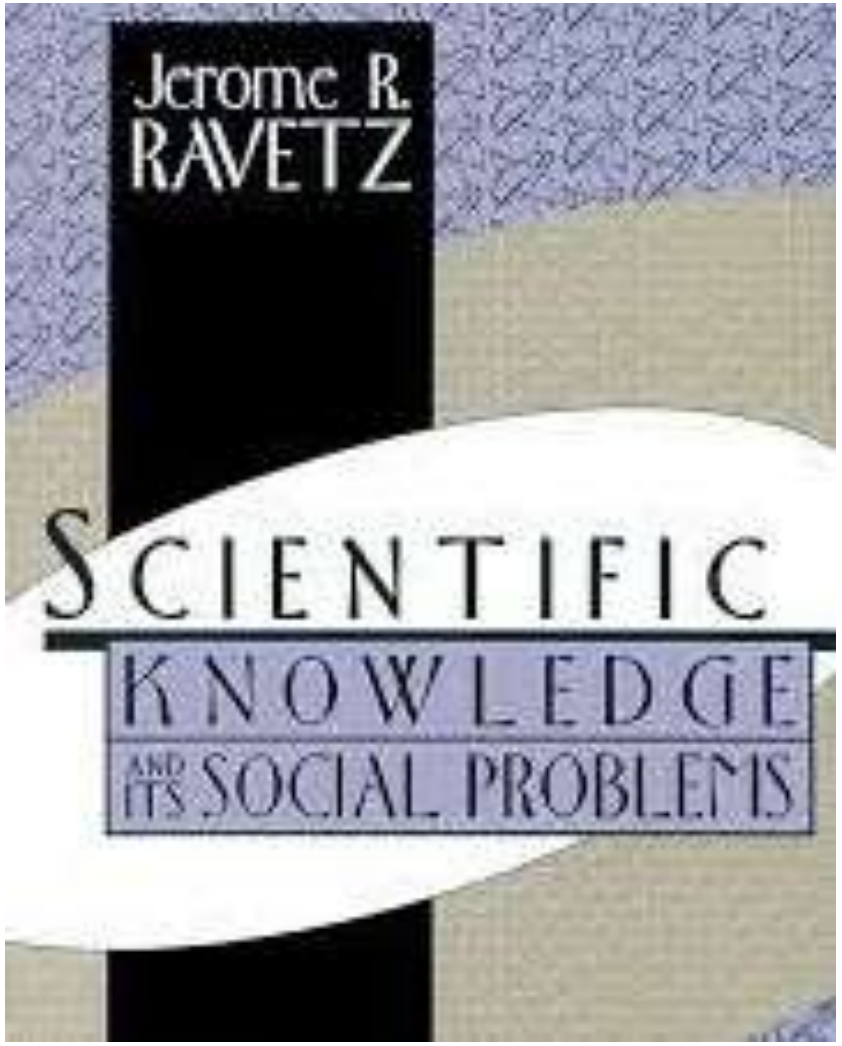
Mostly provided by models

Solutions to resolve the state of exception

Defog the mathematics of uncertainty

An important issue in mathematical modelling is the management of uncertainty. Uncertainty quantification should be at the heart of the scientific method, and *a fortiori* in the use of science for policy.





Conclusions

Do models need rescuing?

The dangers of public scepticism

Resistances to change

Modellers in defence of the neutrality of models, succumbing to the temptation of ‘Displacement’

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.

Conclusions

Do models need rescuing?

How needed is this rescue? Ravetz (1971, 179) prophesized that entire research fields might become diseased, and noted: "*reforming a diseased field, or arresting the incipient decline of a healthy one, is a task of great delicacy. It requires a sense of integrity, and a commitment to good work, among a significant section of the members of the field; and committed leaders with scientific ability and political skill*."

While statistics has some disciplinary arrangements and committed leaders to react to a crisis, mathematical modelling lacks both.

Jerome R. Ravetz

The End

https://mstdn.social/@AndreaSaltelli/

Abstract: December 12: Models: a state of exception
Models live in a state of exception. Their versatility, the variety of methods, the impossibility of their falsification and their epistemic authority permit mathematical models to escape, better than other instances of quantification, the lenses of sociology and other humanistic disciplines. This endows models with a pretence of neutrality that perpetuates the asymmetry between developers and users. Models are thus underexplored and overinterpreted. While retaining a firm grip on policy, they reinforce entrenched cultures of transforming political issues into technical ones.
To combat this state of exception one should start discussing the reproducibility of models, foster complexity of interpretation rather than complexity of construction, and encourage forms of activism following the French statactivists, aimed to achieve a reciprocal domestication between models and society. To breach the solitude of modellers, more actors should engage in practices such as assumption hunting / modelling of the modelling process / sensitivity analysis and auditing.

Reading Material: Saltelli, Andrea, and Monica Di Fiore, eds. 2023. The Politics of Modelling. Numbers between Science and Policy. Oxford: Oxford University Press.

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