Models: a state of exception

Andrea Saltelli

Conference Recent trends in the social studies of quantification
Society for the Social Studies of Quantification and the Centre Maurice Halbwachs (EHESS/ENS-PSL/CNRS), June, 19-20-21, 2024,
Institut Henri Poincaré, 11 Rue Pierre et Marie Curie, 75005 Paris

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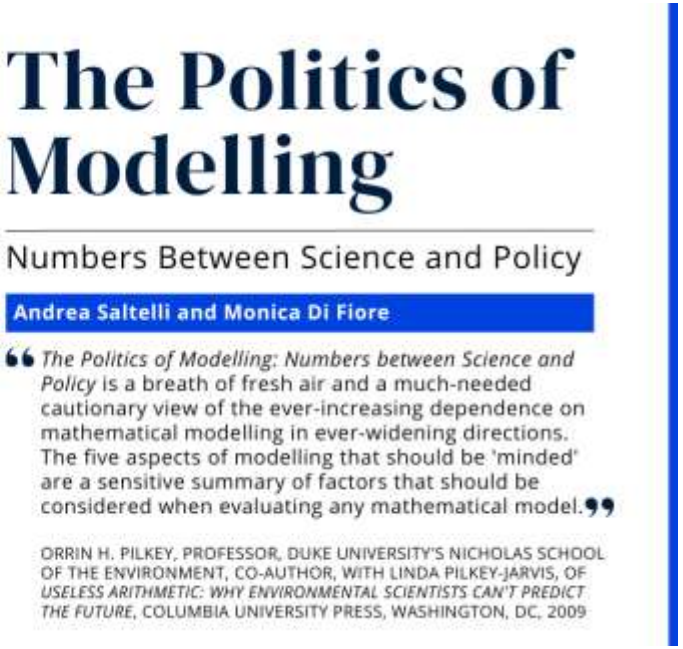

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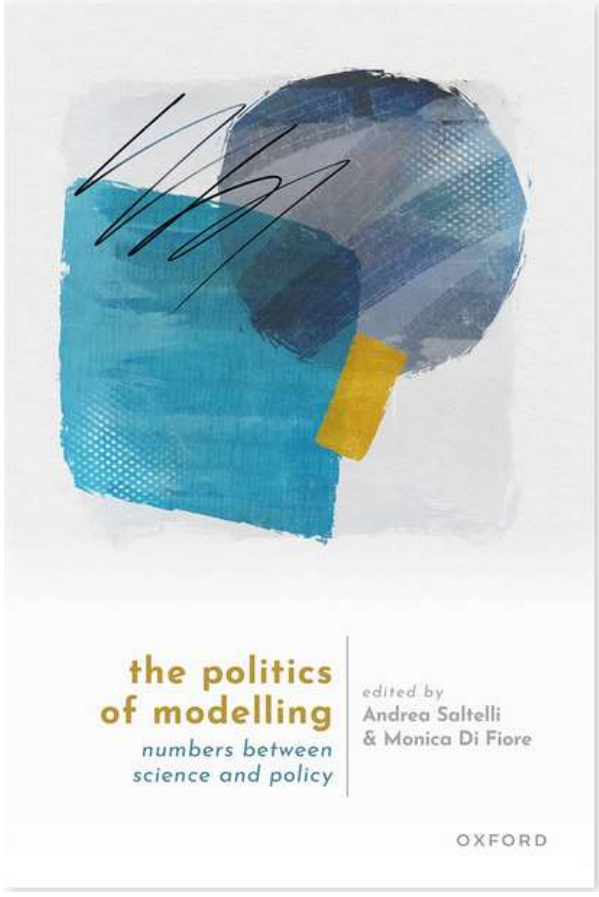
August 25 2023: The politics of modelling is out!



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.

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Do we live immersed in fantastic numbers?

OPINION

PETER COY

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

Sept. 17, 2021

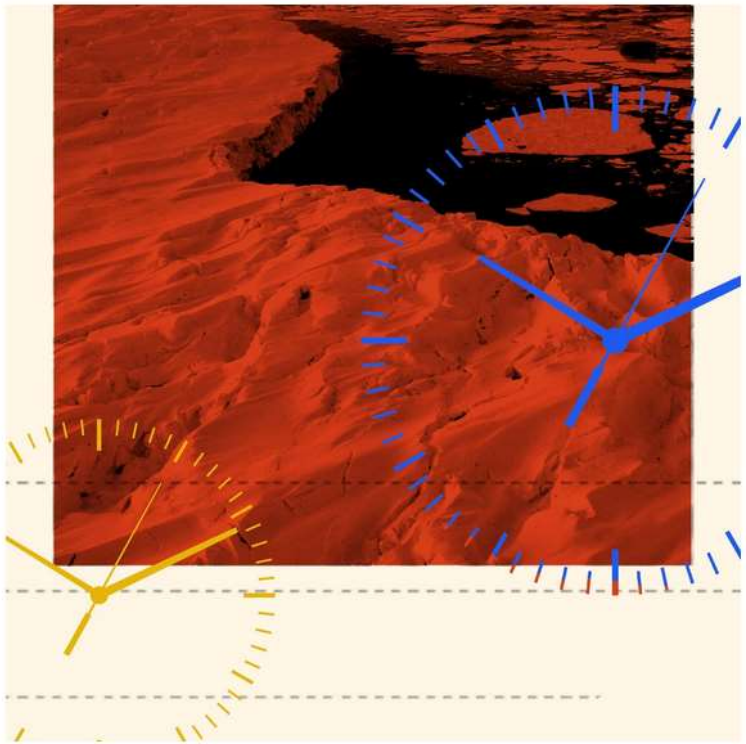


Illustration by Arsh Raziuddin, The New York Times

“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

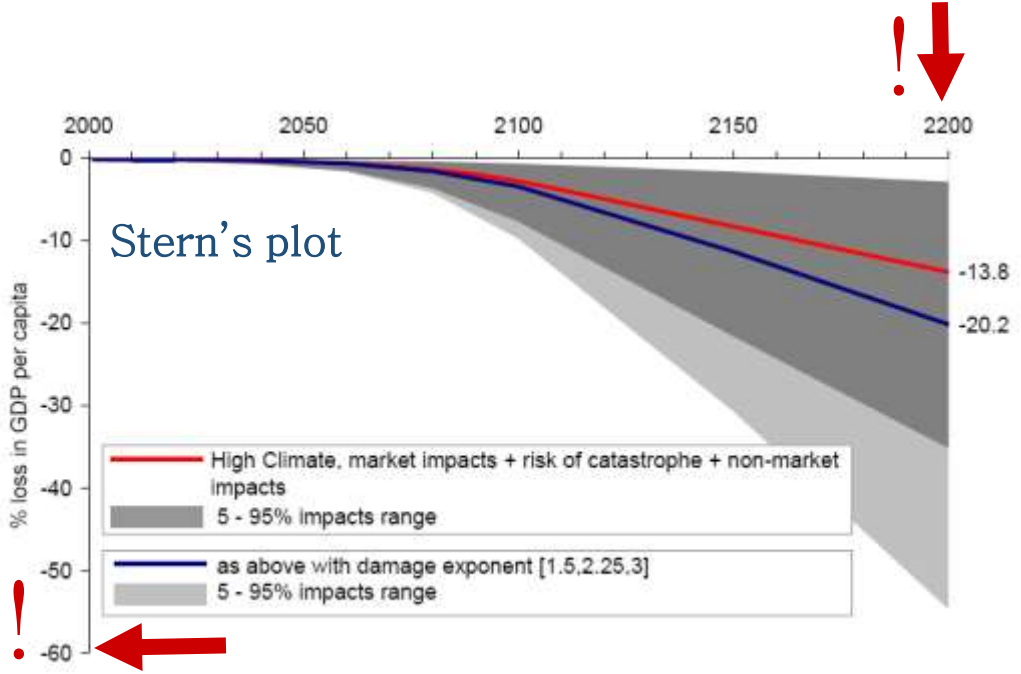
RESOURCES *for the* FUTURE

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

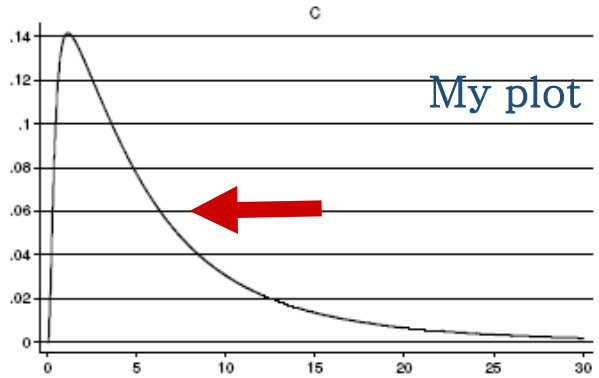
Global Environmental Change

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

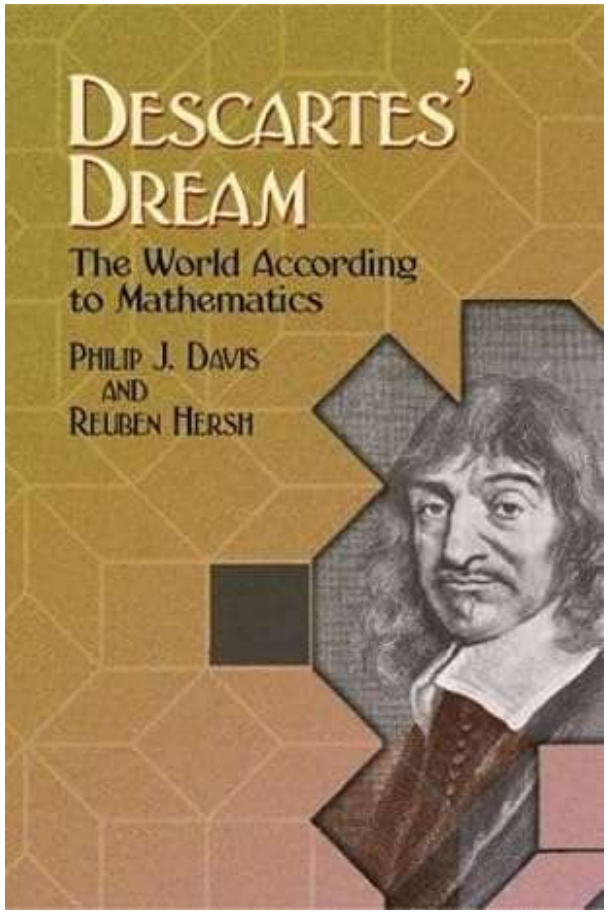
Sensitivity analysis didn't help. A practitioner's critique of the Stern review

Andrea Saltelli *, Beatrice D'Hombres

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

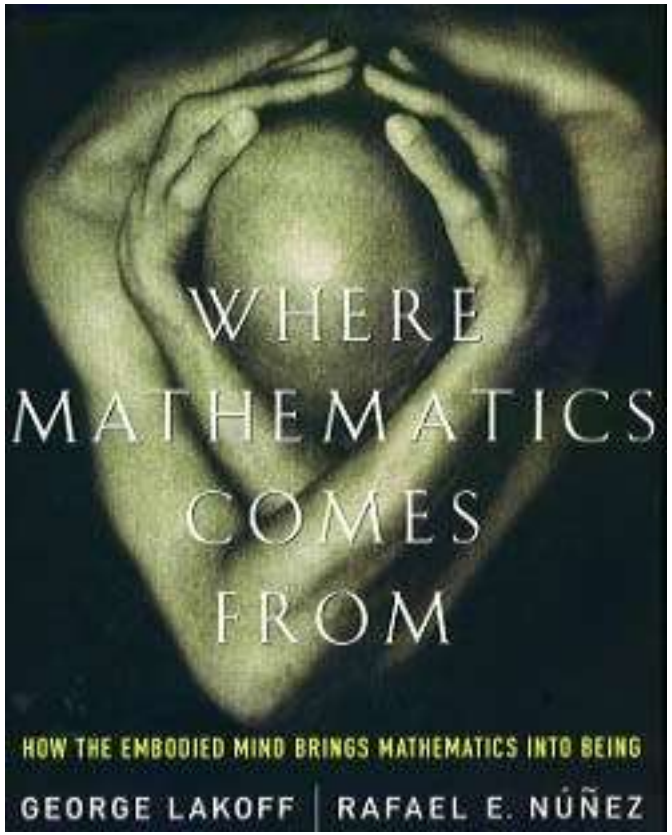


Why models live in a state of exception



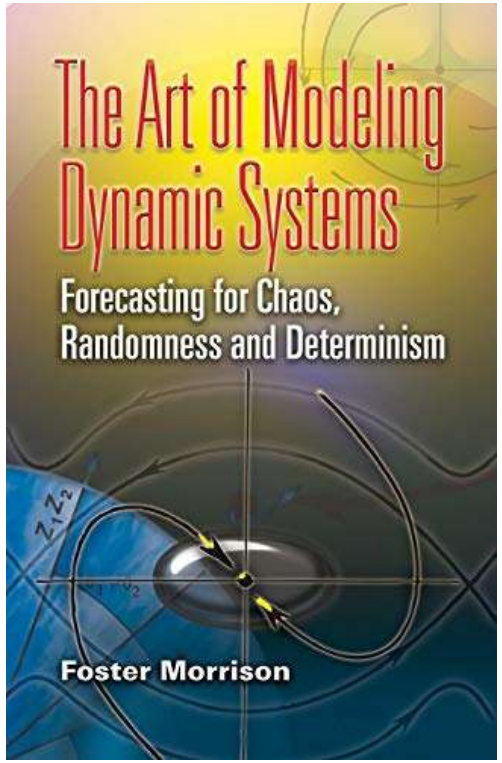
Unparalleled palette of methods / epistemic authority

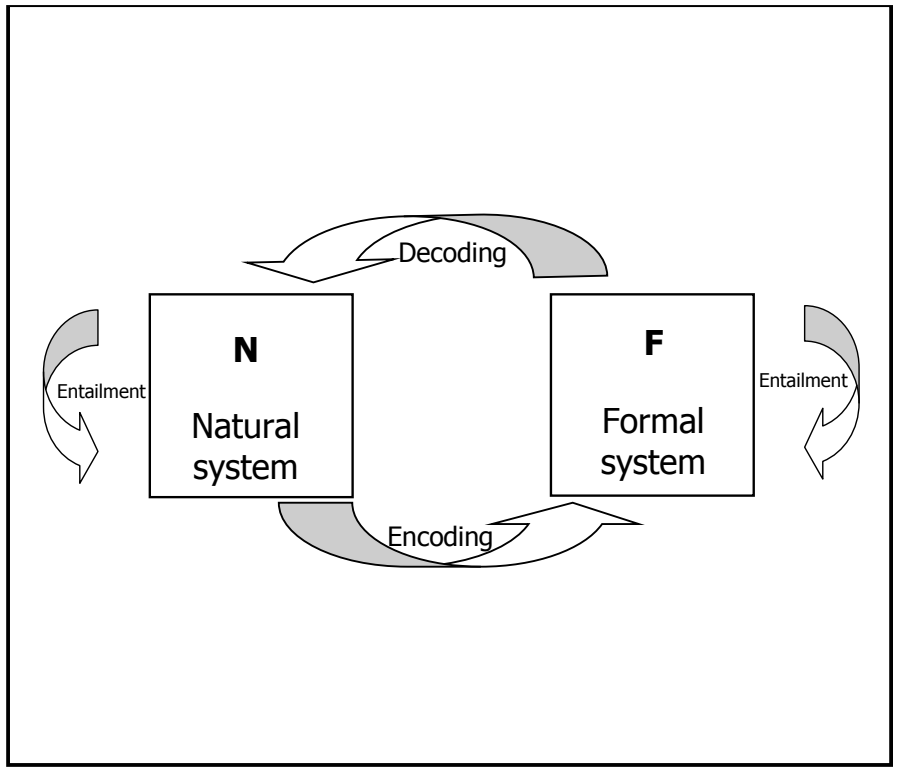
Models dispose of a unique repertoire of methods. Are endowed with unparallel epistemic authority that originates from mathematics, the highest ranked among scientific disciplines (Davies & Hersh, 1986), considered by the fathers of the scientific revolution the language of God himself, up to the point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

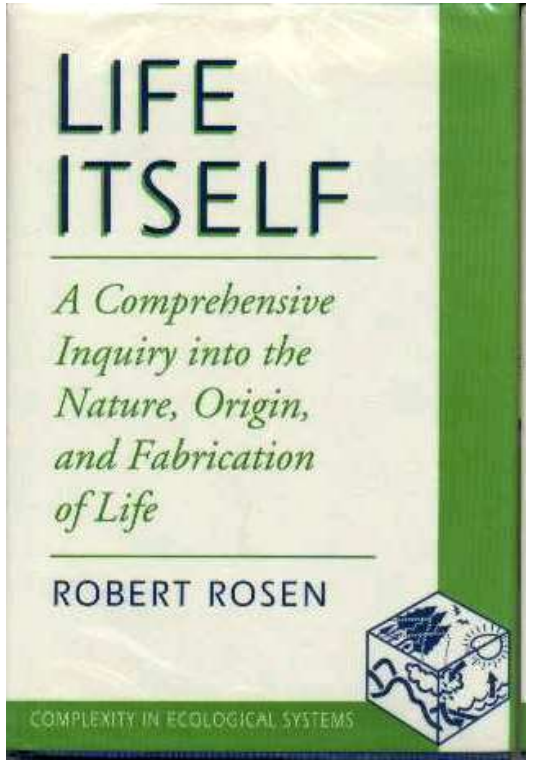


Why models live in a state of exception

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



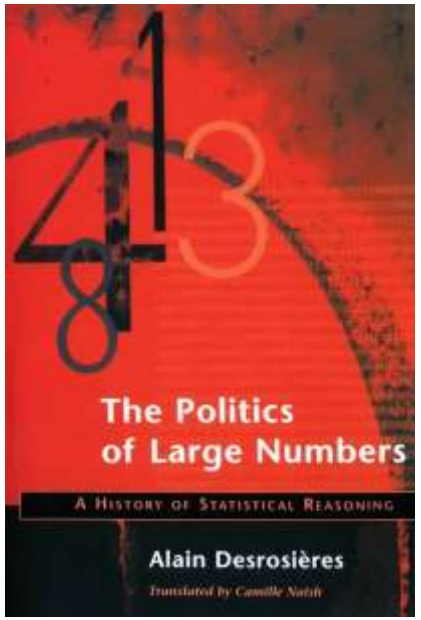




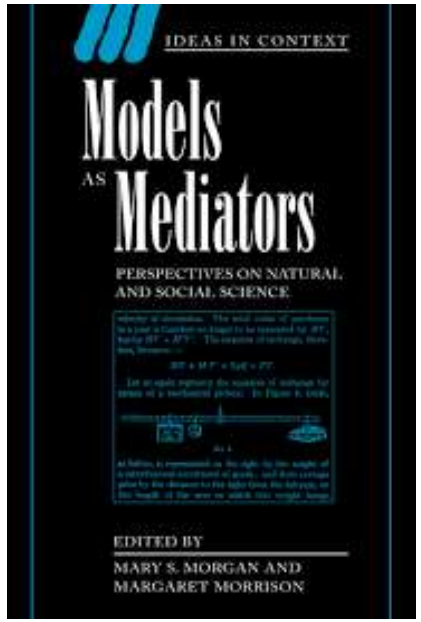
Louie, A.H. 2010. "Robert Rosen's Anticipatory Systems." Foresight 12 (3): 18–29.
Padilla, J. J., Diallo, S. Y., Lynch, C. J., & Gore, R. (2018). Observations on the practice and profession of modeling and simulation: A survey approach. SIMULATION, 94(6), 493–506.

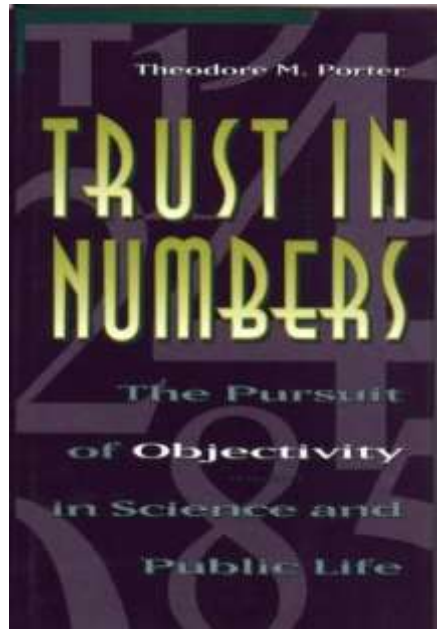
Why models live in a state of exception

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

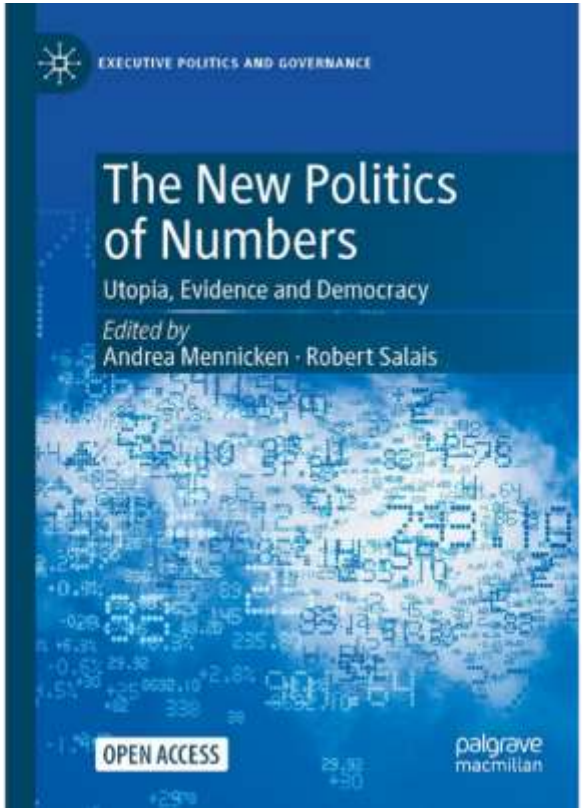
Model have a better pretense to neutrality than other instances of quantification

A technical proof of quality is illusory without a parallel investigation of normative quality; the example of indicators of employment

Technical Quality

Normative quality

Justice: Means versus Freedoms
Author(s): Amartya Sen
Source: *Philosophy & Public Affairs*, Vol. 19, No. 2 (Spring, 1990), pp. 111-121
Published by: Wiley
Stable URL: http://www.jstor.org/stable/2265406
Accessed: 28/10/2014 14:48



Salais, R. (2022). "La donnée n'est pas un donné": Statistics, Quantification and Democratic Choice. In *The New Politics of Numbers: Utopia, Evidence and Democracy*, Andrea Mennicken and Robert Salais, Palgrave Macmillan, pp. 379–415.

Why models live in a state of exception

Mathematical models are extremely malleable

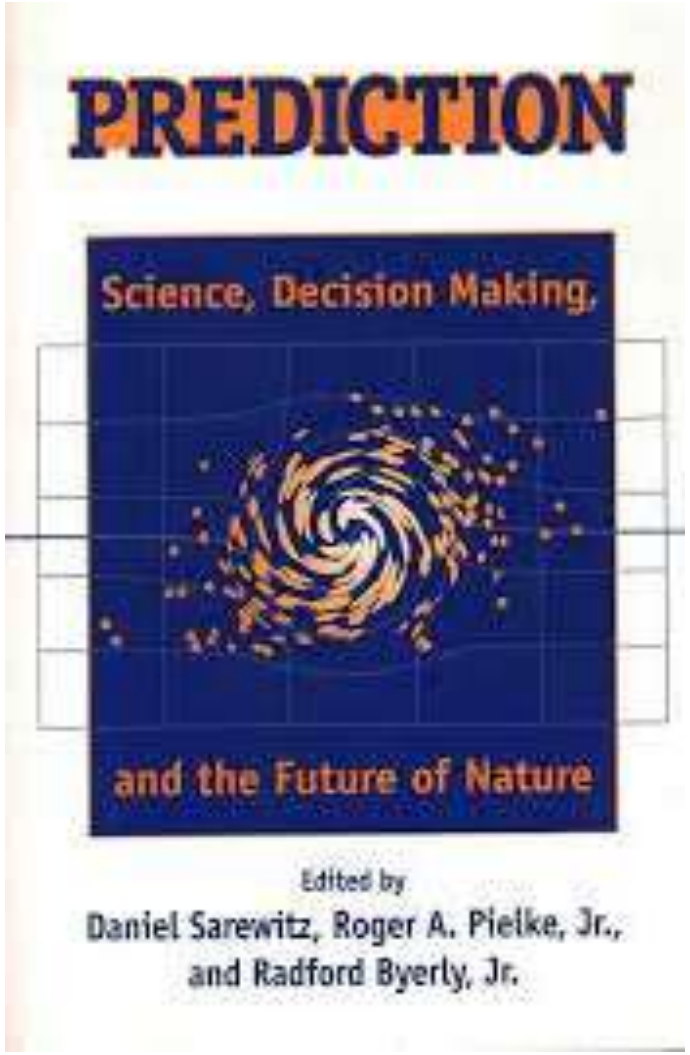
Models lend themselves very naturally to evidence based policy. In statistics you have to reverse the statistical pyramid to achieve the same result – this goes much faster with models

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)

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).

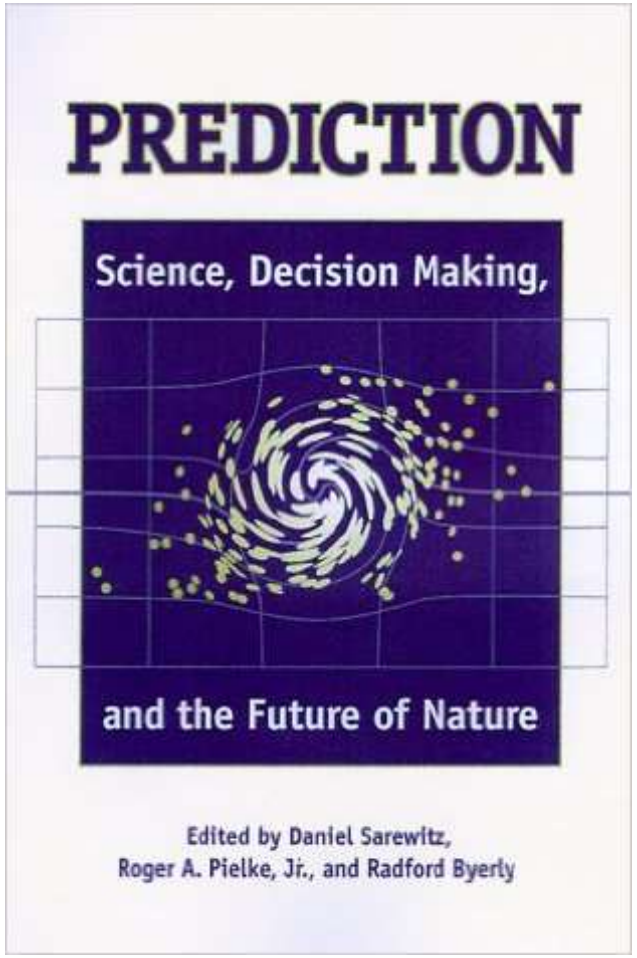


“models are most useful when they are used to challenge existing formulations, rather than to validate or verify them”

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

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

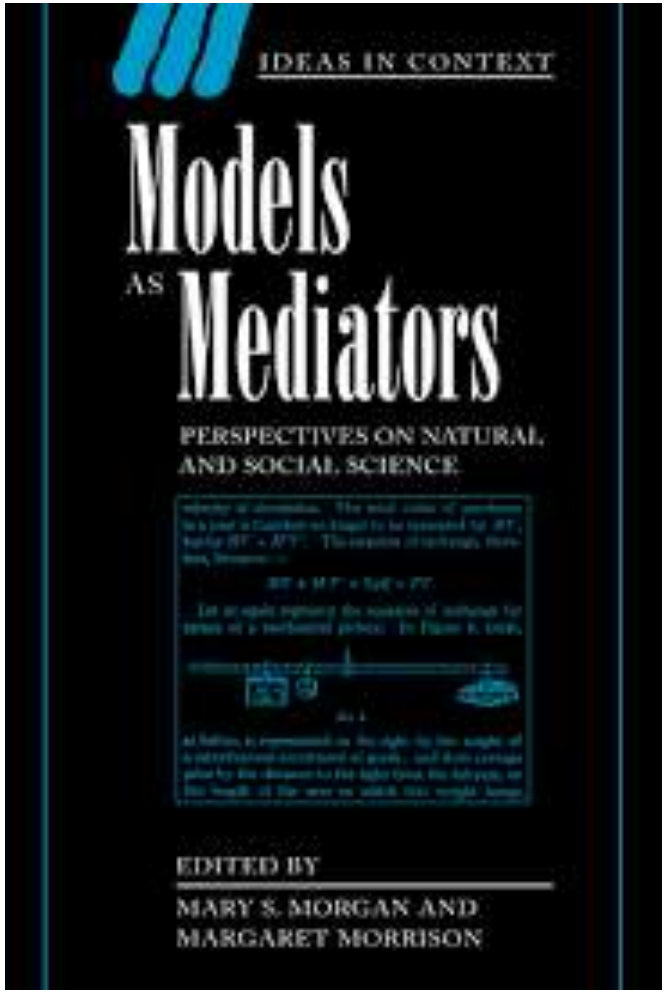
Any part (or several parts) of the model might be in error, and there is no simple way to determine which one it is”

→ Duhem-Quine critique

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).



Why models live in a state of exception

Models as the most effective mediators between theory and reality

Models 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.

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

Mathematical models: a state of exception?

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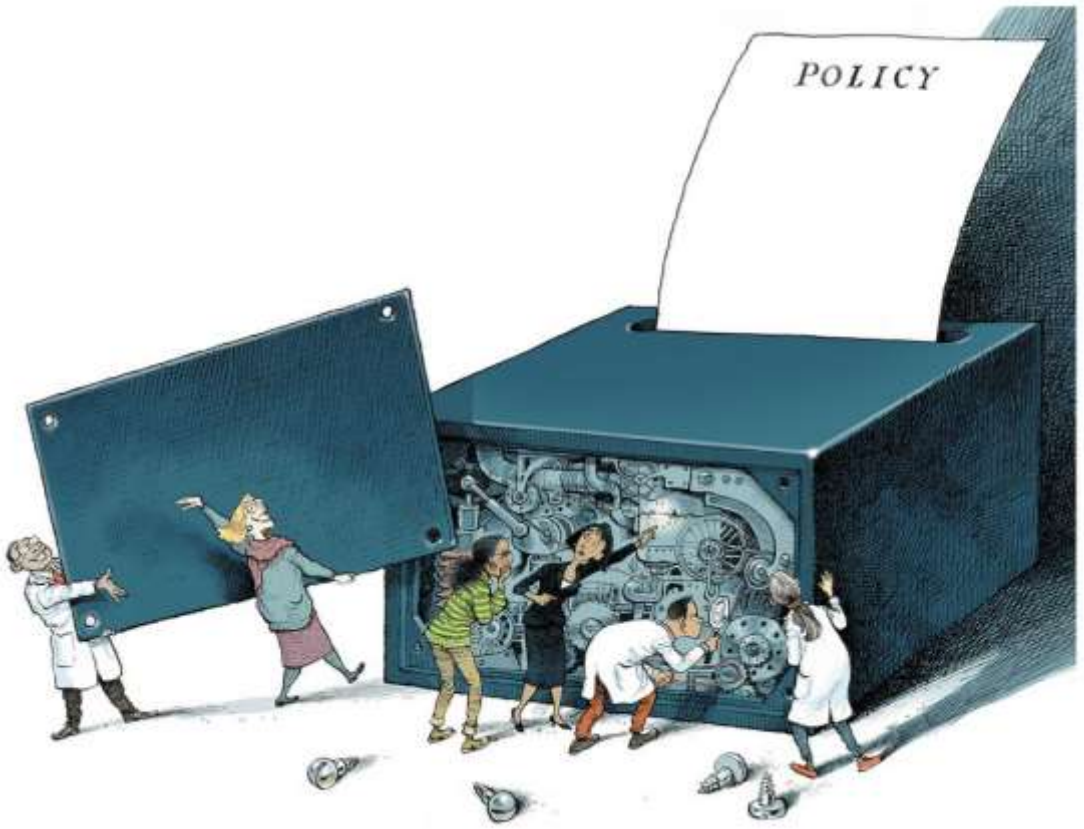
COMMENT | 24 June 2020

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.

By 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

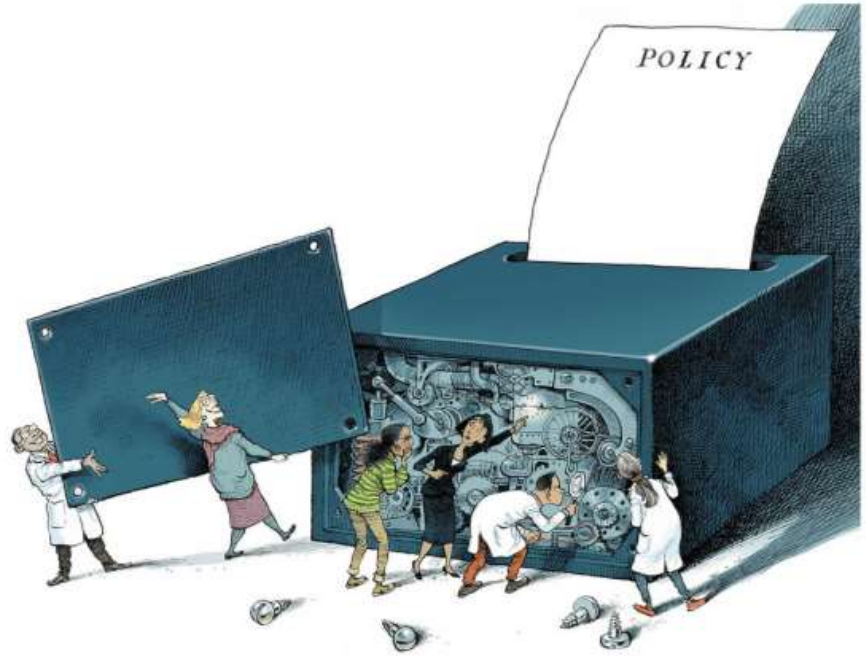


Mind the assumptions

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

Consequences descending from state of exception

Models and trans-science

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

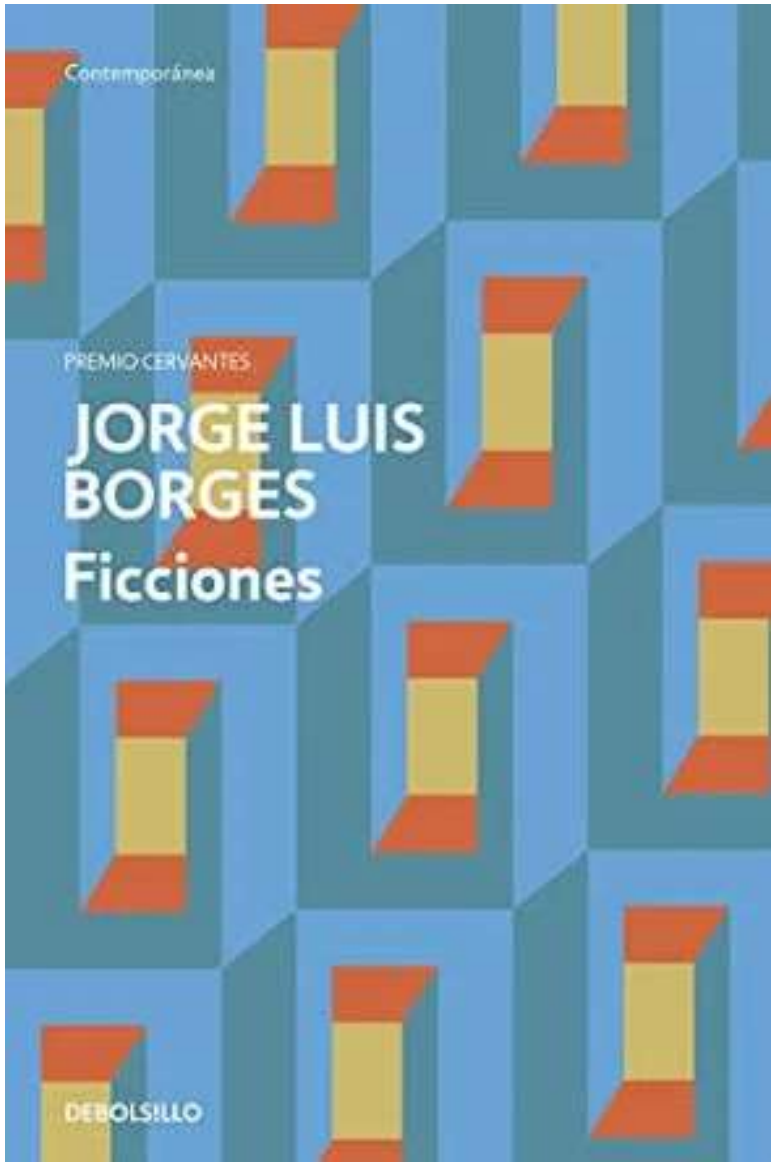
- How many people will sit in autonomous cars by 2050
- How will the spread of malaria change if global temperature increases by 1.5ºC
- What will be the cost of CO2 averaged over the next three centuries

Untitled.webp

Consequences descending from state of exception

Models and trans-science

Model as Jorge LuisBorges' (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

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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.

Digital Twins of th Earth - in the EU Destination Earth

Scientists have built a 'digital twin' of Earth to predict the future of climate change

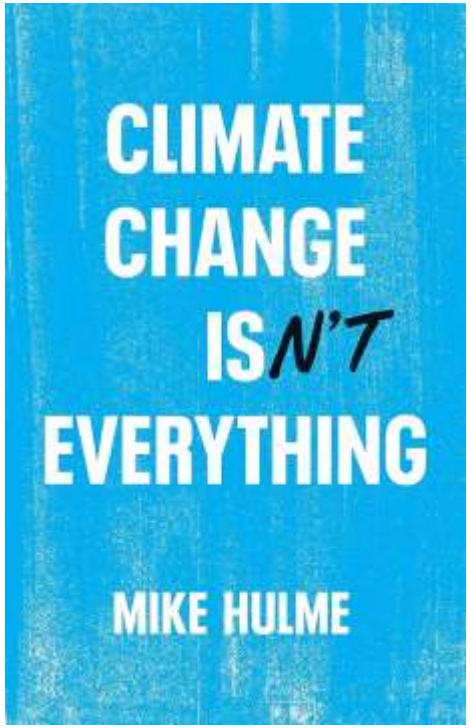
The complex computer model takes into account weather and climate systems as well as our impact on the planet.

> DestinE is true game changer in our fight against climate change.
>
> *- Margrethe Vestager -*

Today, the future is literally at our fingertips

By Rosie Frost & Angela Symons

Published on 11/06/2024 - 16:00 GMT+2 • Updated 16:00



Climate change cannot be the lens through which to look at the world's problems. The war in Syria is not a result of climate change

Rejecting climatic determinism is not a refutation of climate change but of its instrumental use

On the EU plan: Destination Earth

Consequence: Climate became globalized in a new way, seen as a single universal system that could be simulated with – it was believed – increasing degrees of realism, and made predictable. Thus, NASA again: 'New models of the Earth System are now being developed to explore the interactions among the Earth's components and to analyse the global effects of physical, chemical and biological processes . . . these new models will also provide predictions of the effects of global change on human populations.' Global kinds of climatic knowledge – knowledge detached from specific cultural meanings – began to become dominant. This long-standing promise of prediction is alive and well today, as illustrated by the EU's 'Destination Earth' project. This project aims to develop by 2030 a highly accurate digital model of the Earth to monitor and predict with unrivalled precision the interaction between natural phenomena and human activities.[9]

Move 3: *Global temperature was adopted as the dominant index for capturing the condition of all climate–society relationships.*

We have already seen how Nordhaus pioneered the use of global temperature in the 1970s to conduct the first economic analysis of climate/energy policy. Some scientists had been thinking in terms of 'the Earth's temperature' since the nineteenth century. But they had done so in terms of the radiation physics of the world's atmosphere, not in terms of the relationship between climate, people and society. And for most of the twentieth century, scientists had struggled to derive 'global temperature' from empirical observations, as opposed to determining it through theoretical calculation. This began to change during the 1980s. Global temperature began to be employed not just as an index useful

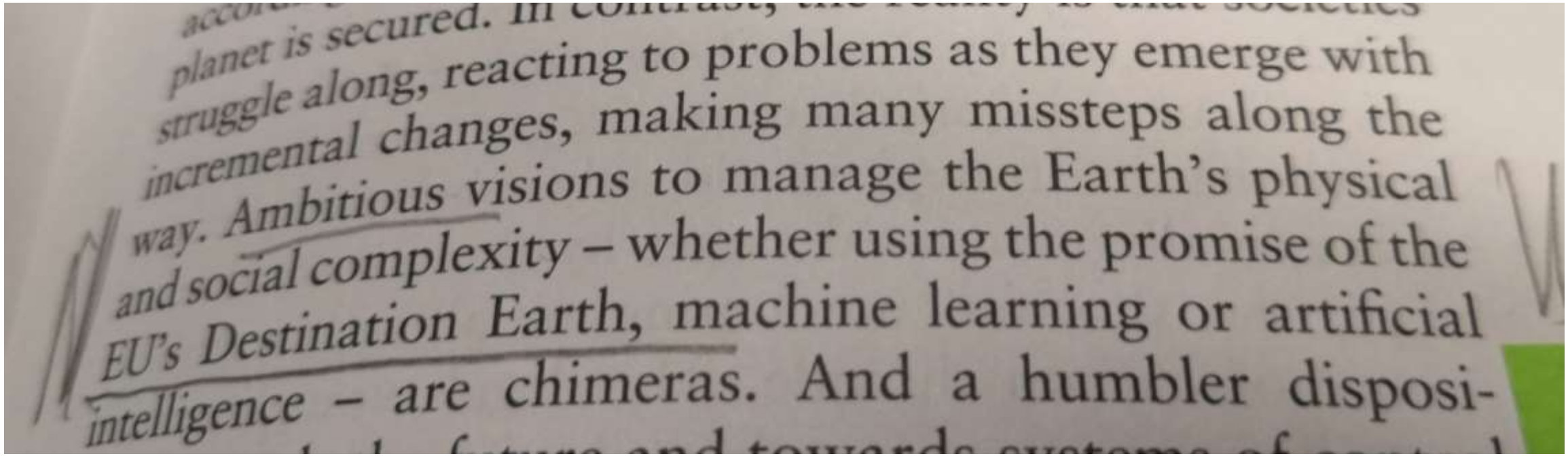
more powerful models will be able to simulate with ever increasing accuracy and precision the future outcomes of complex interdependencies between physical, ecological, social and technological systems. This was Move 6 as described in Chapter 2. And it is exactly what the EU's Horizon Europe research programme promises to deliver by 2030: 'a "full" digital replica of Earth . . . a highly accurate digital model of the Earth to monitor and predict the interaction between natural phenomena and human activities'.[4]

The first step in dismantling climatism is to treat such claims with great scepticism. The sciences and the social sciences are only able – and always will only be able – to see the future 'through a glass darkly'. Adaptation decisions are better made as hedges against a range of uncertain futures than as attempts to optimize based on uncertain predictions. Because of this lack of foreknowledge, policymakers need to know when to look beyond science and embrace other forms of analysis, reflection, wisdom and judgement. Framing, informing and guiding decisions about future policy requires much more than science. By itself, scientific knowledge offers no moral vision, no ethical stance and no political architecture for delivering the sort of worlds that people desire.

'Technologies of humility'

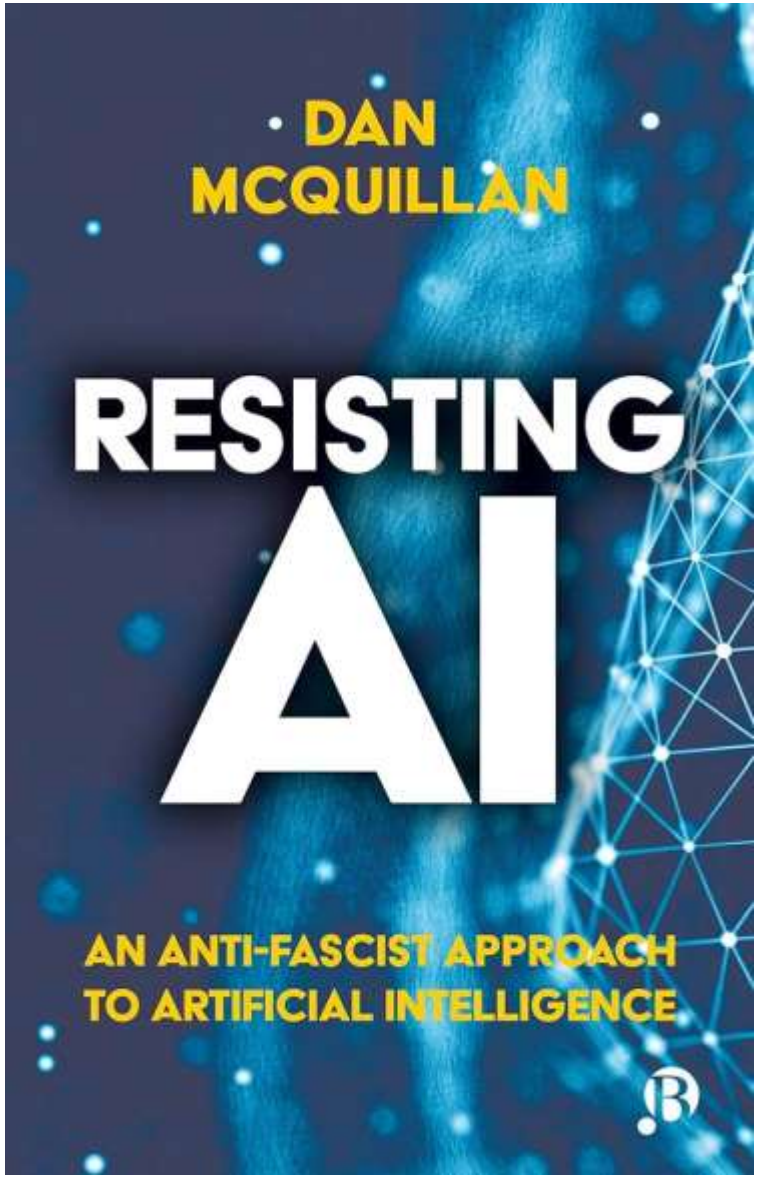
A second antidote to the dangers of climatism follows directly from this. It is to adopt what science studies scholar Sheila Jasanoff has called 'technologies of humility'.[5] By this she means 'disciplined methods to accommodate the partiality of scientific knowledge and to act under irredeemable uncertainty'. In other words, she urges that in the face of the unknown future humility should replace hubris. This is a broader argument

Hulme, Mike. 2023. *Climate Change Isn't Everything: Liberating Climate Politics from Alarmism*. 1st edition. Medford: Polity.



planet is secured. In contrast, the reality is that societies struggle along, reacting to problems as they emerge with incremental changes, making many missteps along the way. Ambitious visions to manage the Earth's physical and social complexity – whether using the promise of the EU's Destination Earth, machine learning or artificial intelligence – are chimeras. And a humbler disposi-

Destination Earth's nature-based metaphors: "Digital ecosystems", "evolutionary development", "data lakes" and "digital species" … and yet we will need AI to read the output of Digital Twins



AI may as a continuation and reinforcement of bureaucratic forms of discrimination and violence, ultimately fostering authoritarian outcomes

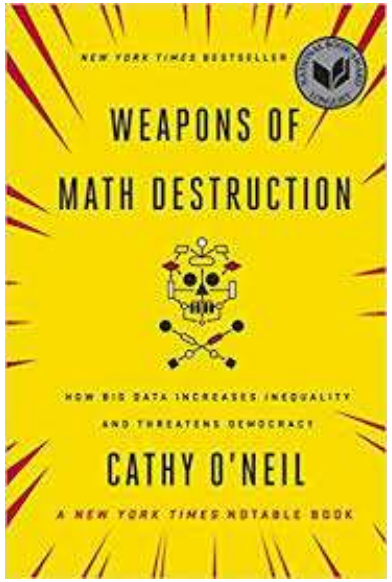
AI's promise of objective calculability is antithetical to an egalitarian and just society

Opaque algorithms to discriminate against categories of people in accessing jobs, loans, medical care…

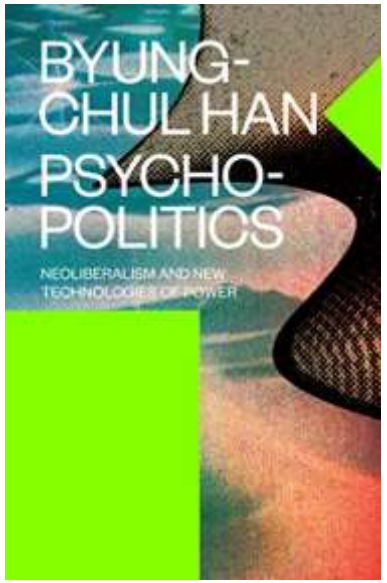
Powered by algorithms, governance by (visible and invisible) numbers contributes to a loss of democratic agency (a-democracy for Salais, fascism for Mc Quillan, refeudalization for Supiot…)

2015
(jurist)

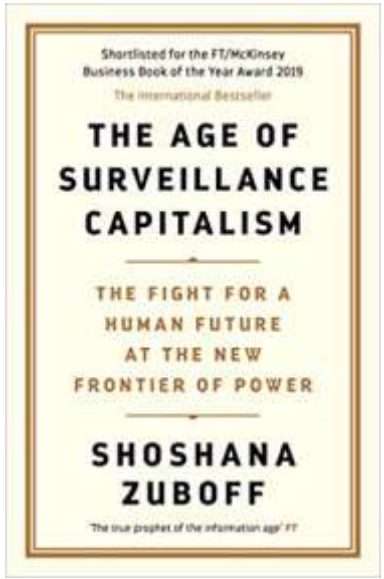
2016
(data scientist)



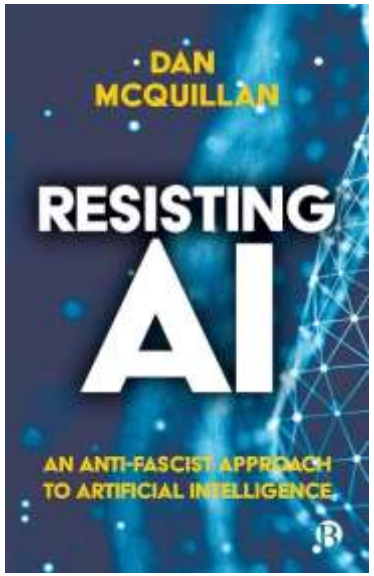
2017
(philosopher)



2019
(economist)



2022
(physicist/sociologist)



Global Environmental Change 32 (2015) 211–218

Contents lists available at ScienceDirect

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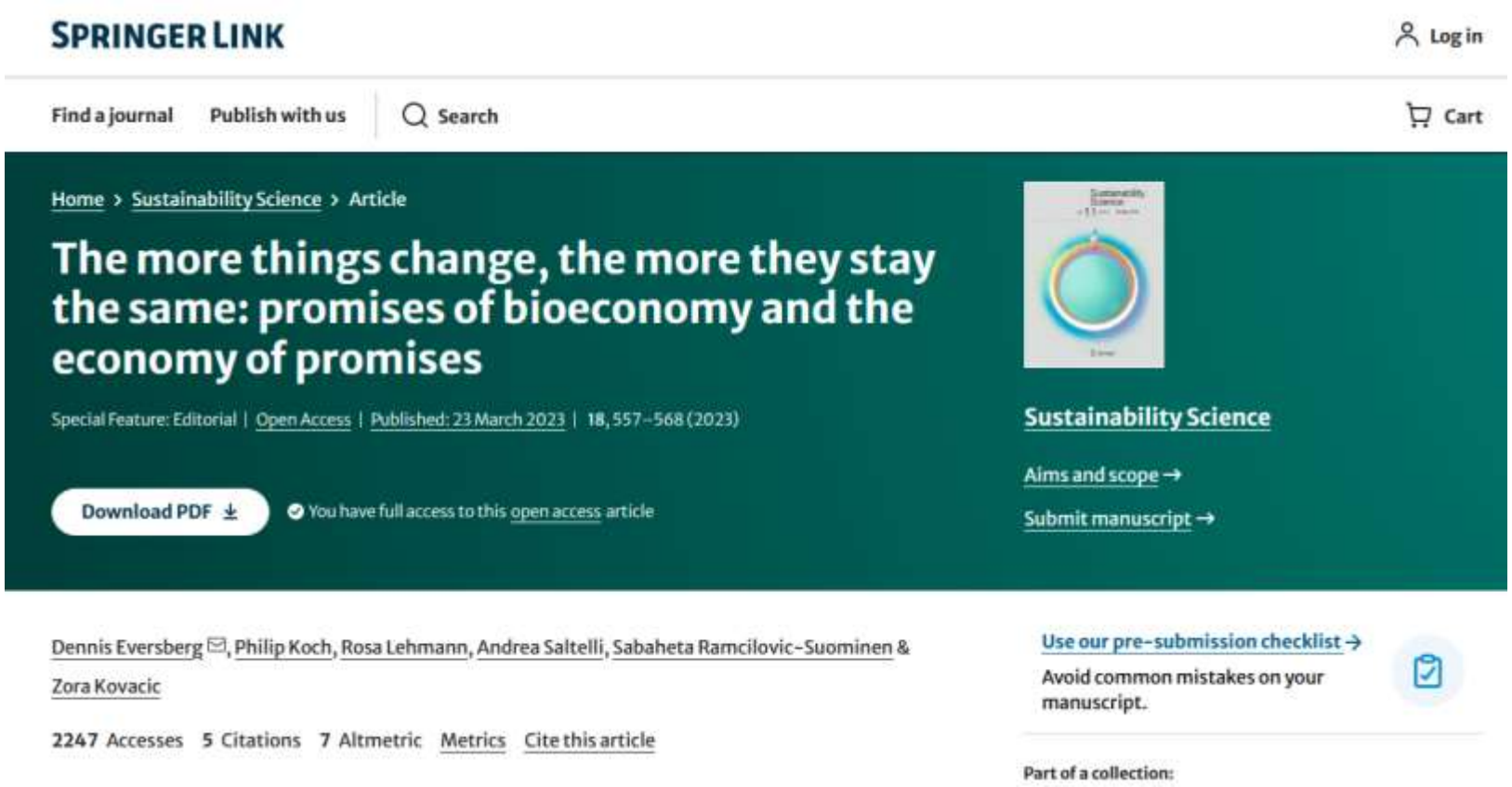
A rare critical work

Who speaks for the future of Earth? How critical social science can extend the conversation on the Anthropocene

Eva Lövbrand [a,*], Silke Beck [b], Jason Chilvers [c], Tim Forsyth [d], Johan Hedrén [a], Mike Hulme [e], Rolf Lidskog [f], Eleftheria Vasileiadou [g]

Anthropocene → One Earth → Destination Earth

Natural-sciences framing of humanity's fate offers a post-social, post-political vision; call to action for critical and interpretative social sciences



More critical work

Debunking promises of circular economy, energy transitions, …

Models for techno-promises

Economics of Techno-scientific Promises' (ETP)= The promise of 'transformation without transformation'

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)

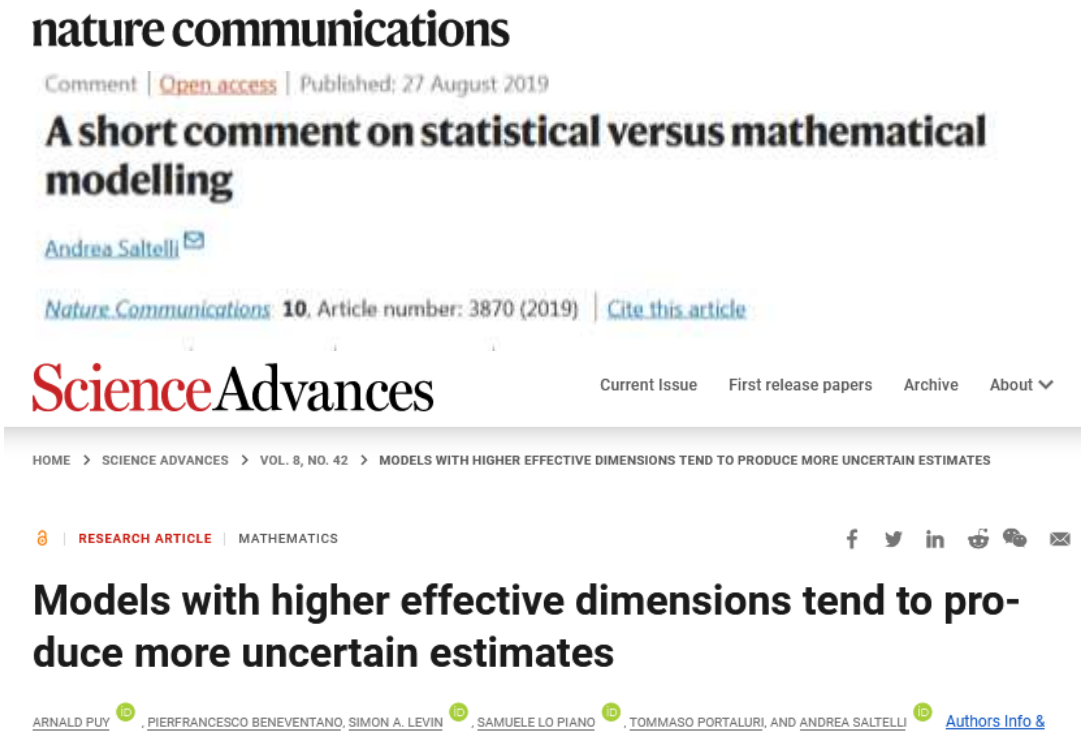
Acting as chameleons, jumping across contexts, Pfleiderer (2020).

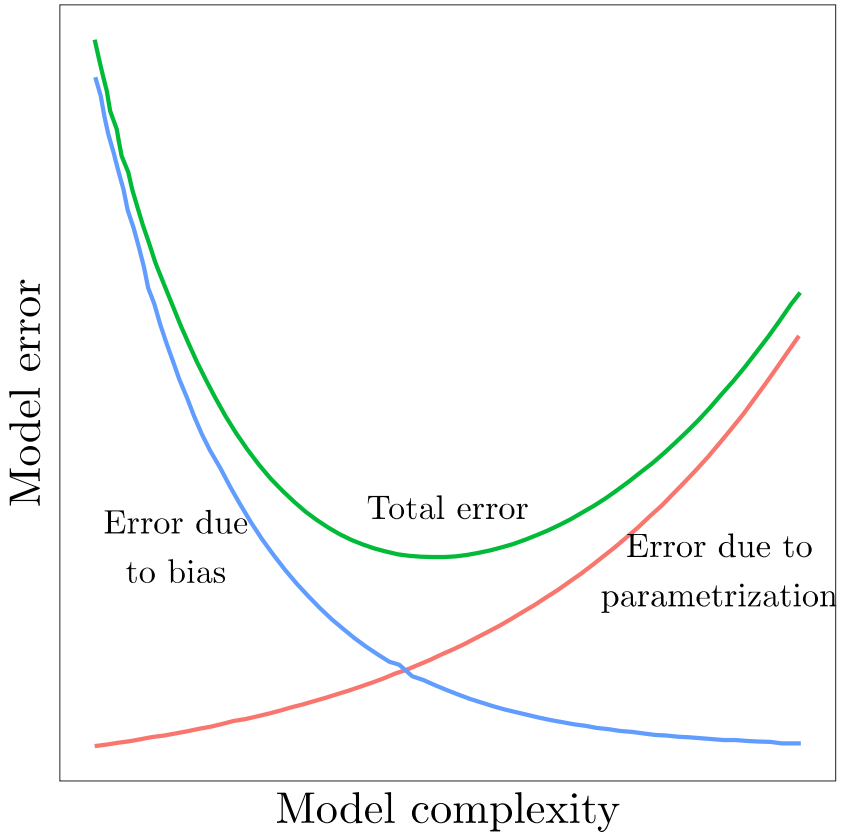
Source: National Geographic

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.





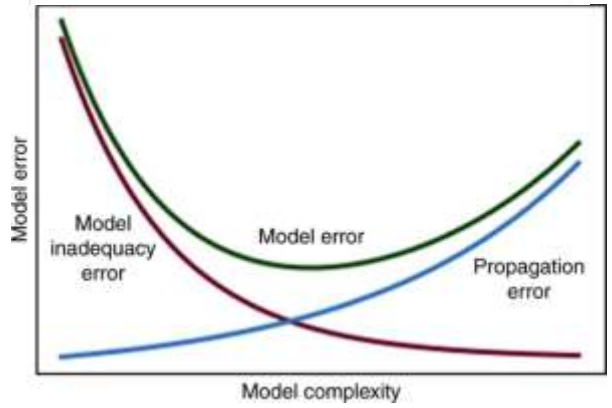
Solutions to resolve the state of exception

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

…



➔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

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

SCIENCE · 26 Mar 1971 · Vol 171, Issue 3977 · pp. 1212-1217 · DOI: 10.1126/science.171.3977.1212

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?

Journal of Evaluation in Clinical Practice
International Journal of Public Health Policy and Health Services Research

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COMMENTARY | Open Access

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

Andrea Saltelli, Joachim P. Sturmberg, Daniel Sarewitz, John P. A. Ioannidis

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

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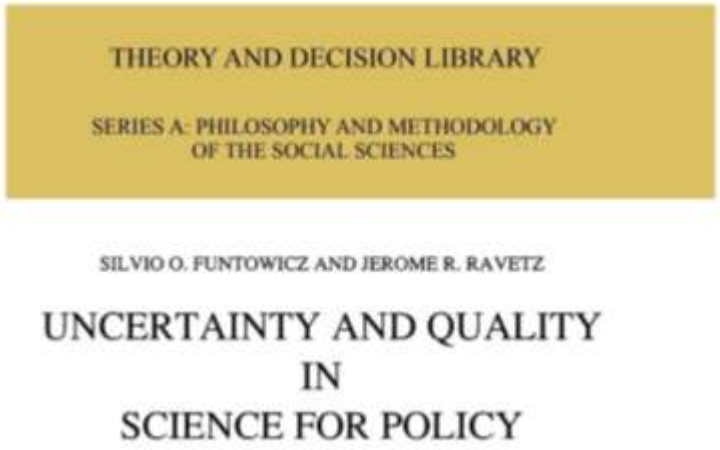
"COVID-19 policies allocated sacrifice, privation and suffering across all walks of society [but] radically different responses from nation to nation—from draconian lockdowns, to relatively permissive and flexible pandemic regimes—made obvious to all that the value of scientific evidence was to support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

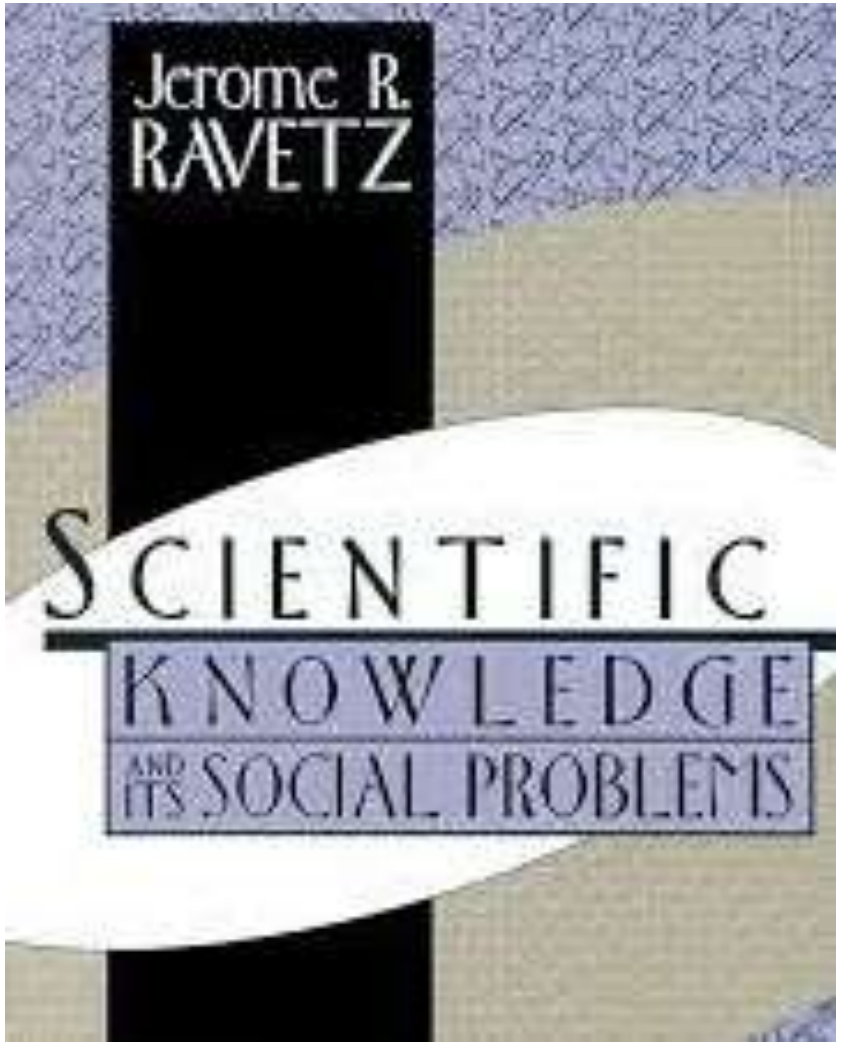
Mostly provided by models

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 at the heart of the scientific method, and *a fortiori* in the use of science for policy.





Solutions to resolve the state of exception: adopt more lenses

Environmental Science and Policy 142 (2023) 99–111

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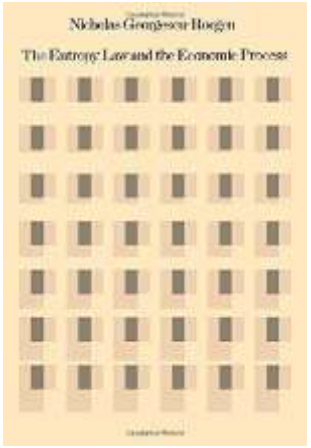
journal homepage: www.elsevier.com/locate/envsci

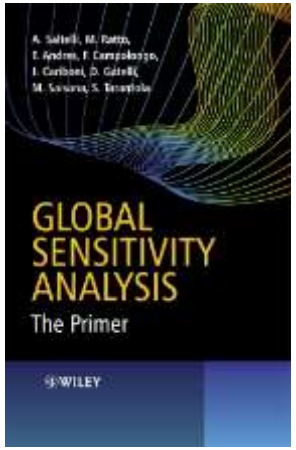
Impact assessment culture in the European Union. Time for something new?

Andrea Saltelli [a,b,*], Marta Kuc-Czarnecka [c], Samuele Lo Piano [d], Máté János Lőrincz [d], Magdalena Olczyk [c], Arnald Puy [e], Erik Reinert [f,g], Stefán Thor Smith [d], Jeroen P. van der Sluijs [b,h]

Proposed lenses

- Non-Ricardian economics
- Bioeconomics (in the sense of Nicholas Georgescu-Roegen)
- Approaches originated in the context of post-normal science
  - global uncertainty and sensitivity analysis
  - sensitivity auditing
  - NUSAP
  - quantitative storytelling





Contrasting invisibilities

Non-Ricardian economics: invisibility of qualities, whereby all hours of work are taken to have the same value

Bioeconomics: invisibility of nature, whereby natural resources are considered as infinite or infinitely substitutable

Post-normal science: invisibility of values, obfuscated by the purported neutrality of quantification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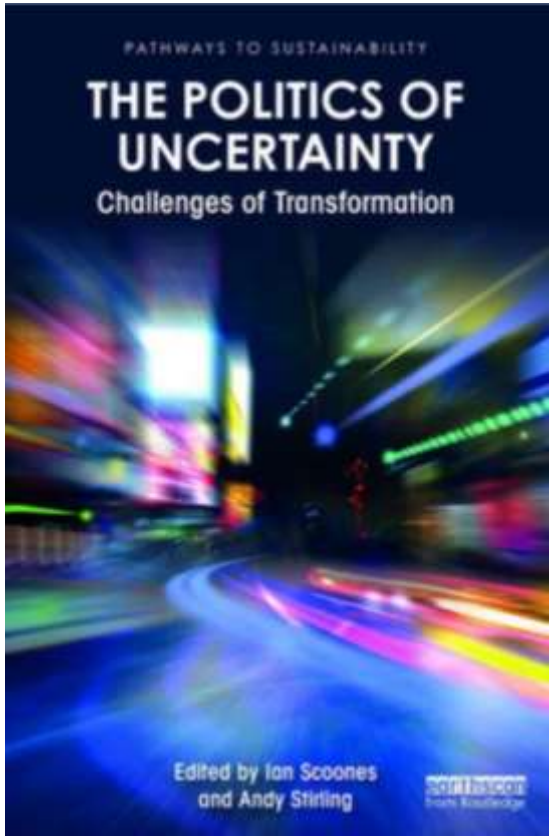
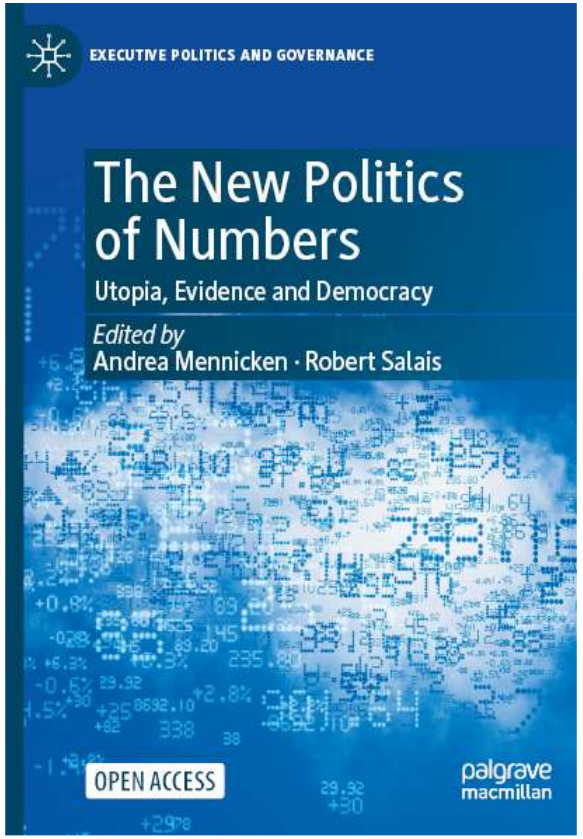
Nicholas Georgescu-Roegen

Erik S. Reinert

Jerome Ravetz and Silvio Funtowicz



2020



2022

2023

Reveal the policy of the numbers

Conclusions

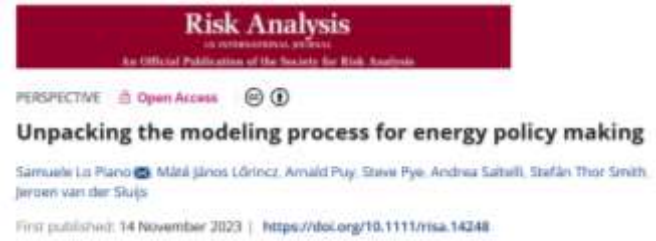
"models are more symbolic vehicles for gaining authority than objective technical framework" (1984)

The same way Digital Twins of the planet are 'scientifically prescribed' today …

Brian Wynne (and others such as William Keepin) debunked in the early 80's a totally off-the-mark model-based energy future, declared as 'scientifically prescribed' by analysts at IIASA …

A fast breeder reactor in the Netherlands, today an amusement park

See a summary here



END

Summary, references and extra slides below

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.

Based on: Saltelli, Andrea, Arnald Puy, and Monica Di Fiore. 'Mathematical Models: A State of Exception'. International Review of Applied Economics June 11 (2024). https://doi.org/10.1080/02692171.2024.2365727

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