TWIN POLITICS

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

universität wien

erc European Research Council

upf. BARCELONA SCHOOL OF MANAGEMENT

UNIVERSITAS BERGENSIS

TwinPpolitics Ocean Seminar

The Limits of Models in Creating Digital Twins of the Earth

Andrea Saltelli, May 13, 2026 | 5:00-7:00 PM (CET)

Based on: Equations of Power: Models, Authority, and the Politics of Knowledge (Anthem Press, 2026)

An ocean digital twin promises decision-ready knowledge of a planetary system. Its credibility rests on climate modelling.

Climate modelling's credibility rests on the authority of science.

When the twin speaks, science speaks.

When the twin is doubted, science is doubted.

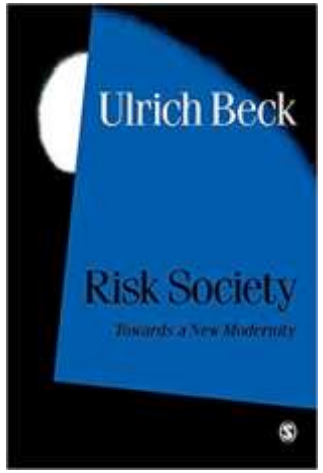
This talk is about this chain — how it was built, what it carries, and what it cannot carry

Based on: Equations of Power: Models, Authority, and the Politics of Knowledge (Anthem Press, to appear 2026)

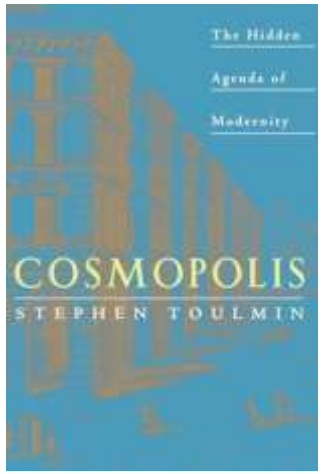
Mathematical modelling has become the epistemic centre of climate science and, with it, a new axis of political polarisation around the authority of science. **How did we get there?**

Science was the ersatz religion of modernity (Toulmin). Few saw the dangers of science (Eisenhower [farewell], Goodman [Vietnam war], Beck [risk society], …)

Those few lost the war



Ulrich Beck
(1944 –2015)



Stephen Toulmin
(1922-2009)

Those few lost the war

Polarisation won

Diffidence toward science is now the preserve of large political families

"The polarization of trust in science is a complex phenomenon shaped by—and increasingly also shaping—American political identities"

HOME / ARCHIVES / VOL. 4 (2018) / Debates/Interactions

Why We Can't Have Our Facts Back

Noortje Marres
University of Warwick

DOI: https://doi.org/10.17351/ests2018.188

Keywords: demarcation, knowledge technology, knowledge democracy, digital society, public facts

PUBLISHED
24 Jul 2018

PDF

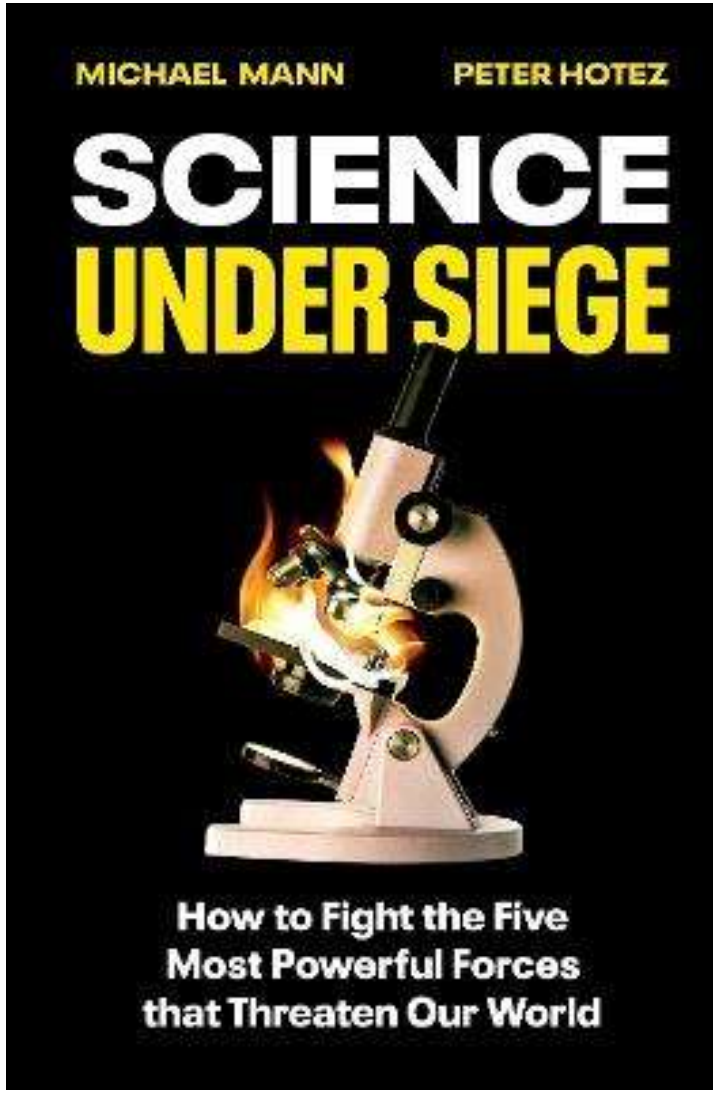
ISSUE
Vol. 4 (2018)

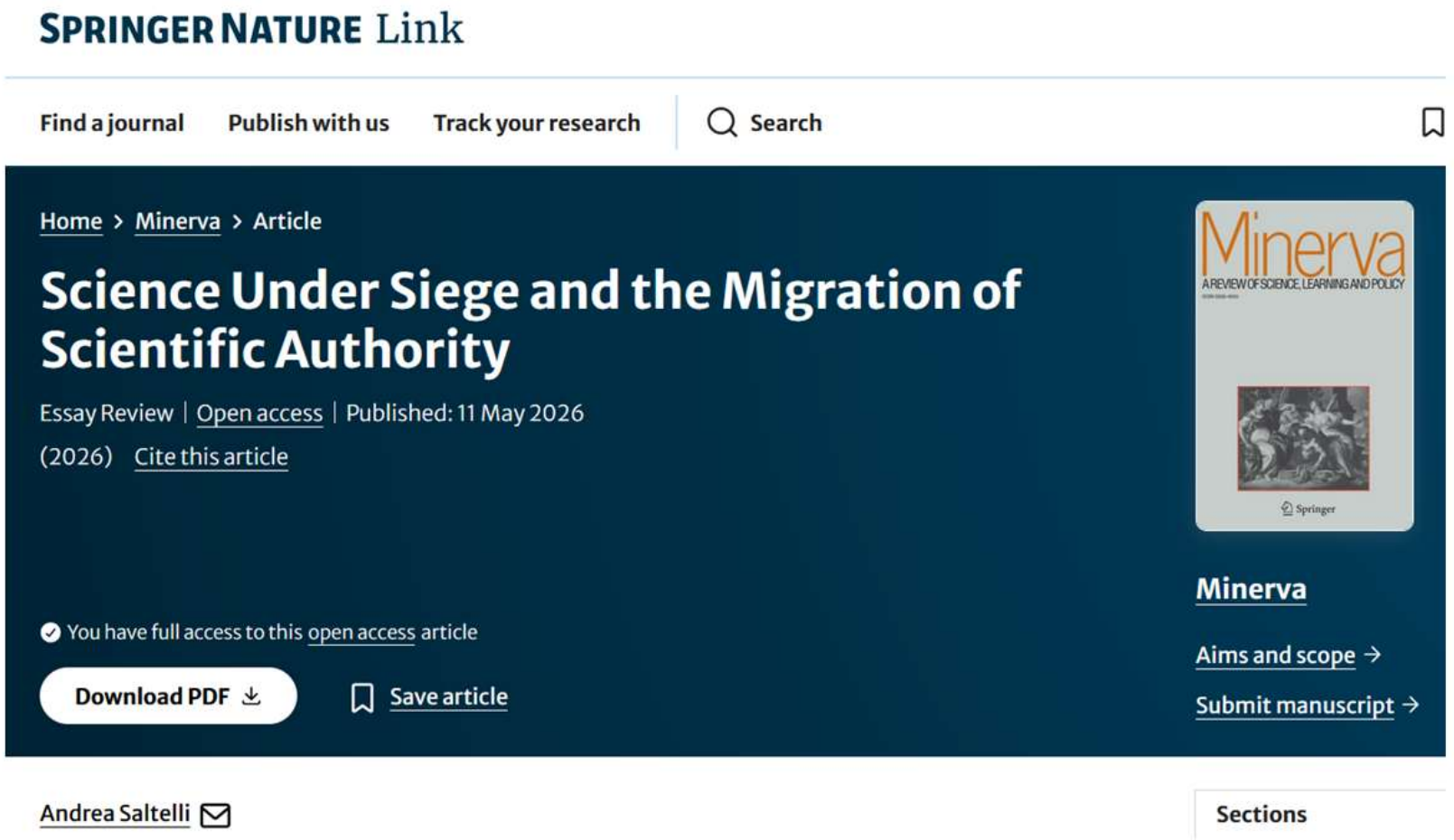
On all important matters involving the authority of science [e.g., vaccines Barrington, climate DOE report], the terrain is divided

Opposing fields deploy along party lines

… But we cannot have our facts back

We cannot have our facts back ➔ “We have truth and justice on our side” is not the right approach





- Climate stands for science
- Science stands for progressives [whatever this means]
- The urgency of fighting an impending climatic catastrophe stands as the line separating civilisation from barbarism

What do doubters have to say?

Conspicuous Cognition

https://www.conspicuouscognition.com/

On Highbrow Misinformation

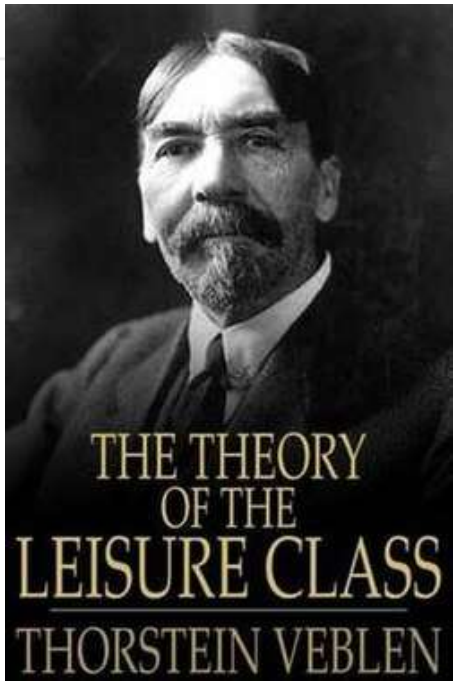
On issues like climate change, gender, race, and crime, establishment journalism and punditry are often misleading. One can acknowledge this without becoming a "contrarian", conspiracist, or bigot.

DAN WILLIAMS

OCT 26, 2025 · PAID

From conspicuous consumption (Veblen) to conspicuous cognition: allegiance to "the science" as a marker of cultural identity and educational distinction

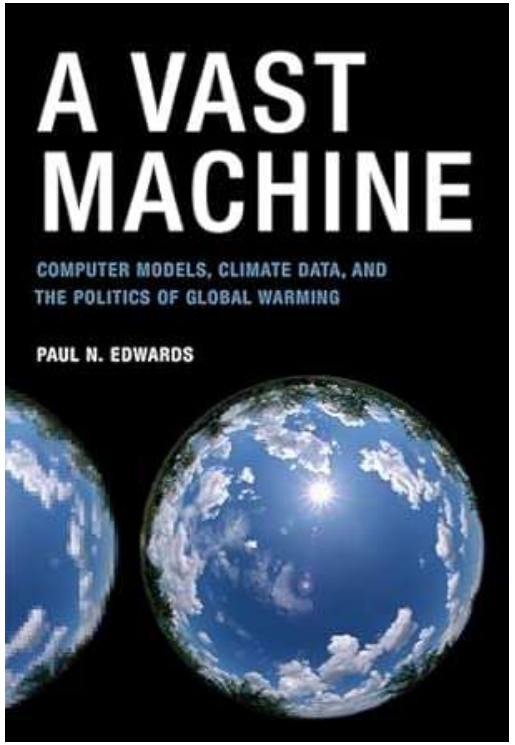
Thorstein Veblen
(1857–1929)

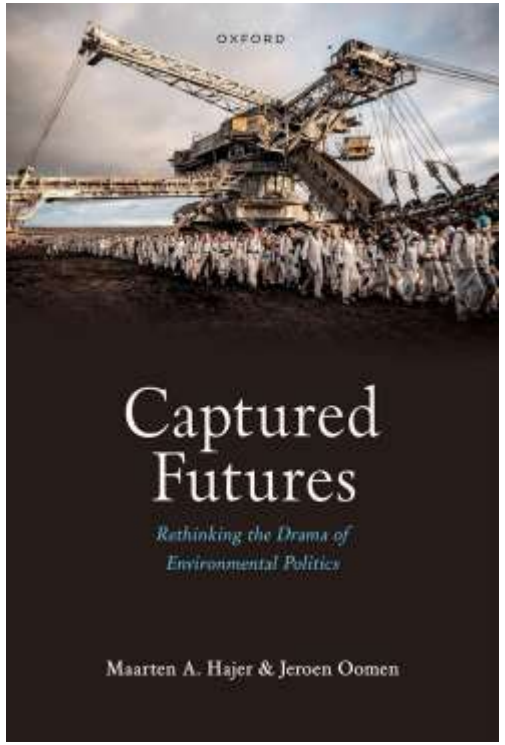


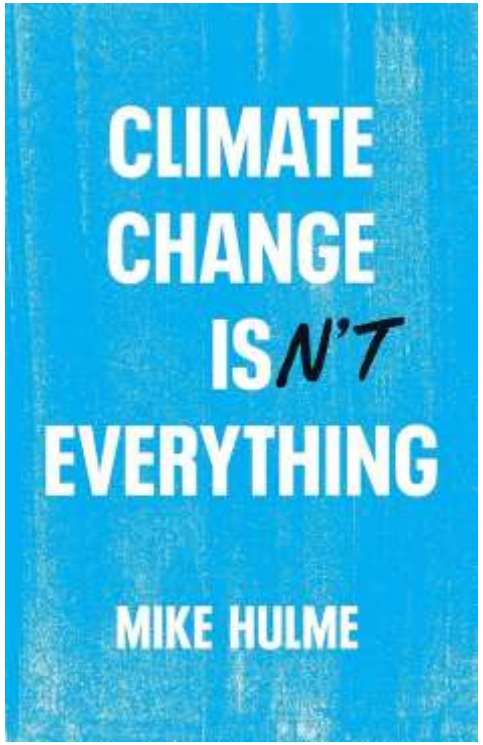
Modern climate modelling and global atmospheric science grew out of Cold War military and geopolitical infrastructure ➔ nuclear war

Mathematical modelling has come to dominate climate change research …

… But climate change isn't everything





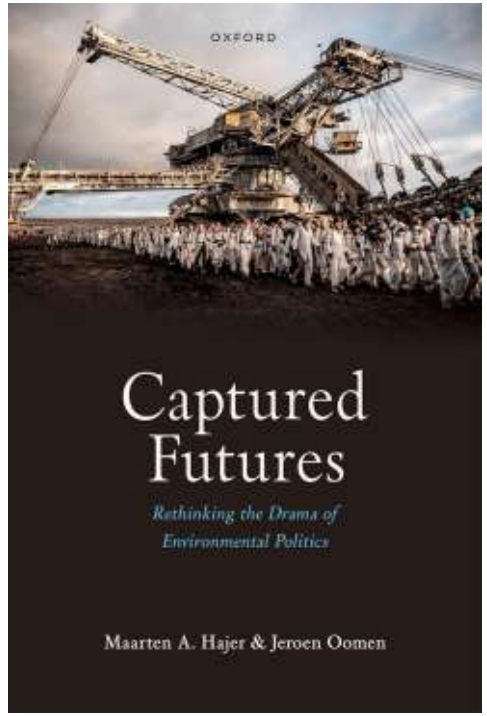


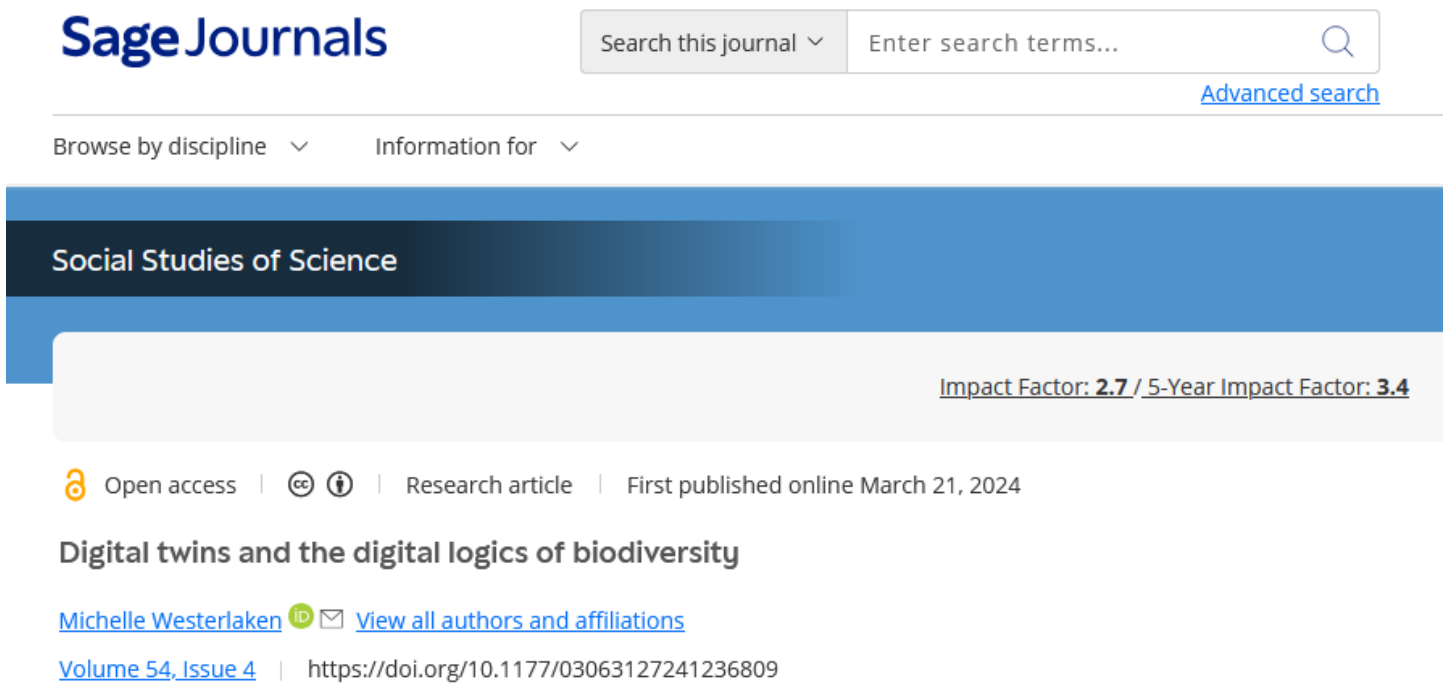
Centrestage: Physics, CO2, global mean temperature, emissions, mitigation

Offstage: Biophysics, system ecology, pollution, society, adaptation

Mike Hulme

Scenarios of decarbonisation, carbon budgets, and temperature targets emerge from modelling practices that translate heterogeneous processes—biological, physical, economic, and social—into tractable computational form





- Modelling funnels debate toward specific policy options.
- Technological solutionism (carbon capture, hydrogen economy, geoengineering).
- Narrative “scripts” that structure how environmental futures are imagined.

Two visions of planetary harm

Messy, local, attributable. Indoor and outdoor air pollution; plastic in the oceans; illegal dumpsites, hexavalent chromium; forever chemicals; eco-mafias; wars; Science is a driver of harm

Global, linear, unified. Greenhouse gas emissions gradually increase temperatures, leading to catastrophic events. Scientists defend the planet

The political economy of the shift

Moving from Vision 1 to Vision 2 implies:

- Systemic → reductionist
- Individual responsibility → diffuse global stewardship

It is unsurprising that scientists, administrators, entrepreneurs and politicians prefer the second over the first

Without forgetting tech philanthropists

Where does the money go? See →
- Mitigation
- Global North

climateworks FOUNDATION

Bill Gates — nuclear, geoengineering research funding, How to Avoid a Climate Disaster

Jeff Bezos — Bezos Earth Fund, Amazon Web Services as the compute substrate for climate modelling

Sam Altman — OpenAI, Helion fusion, the "AI will solve climate" framing

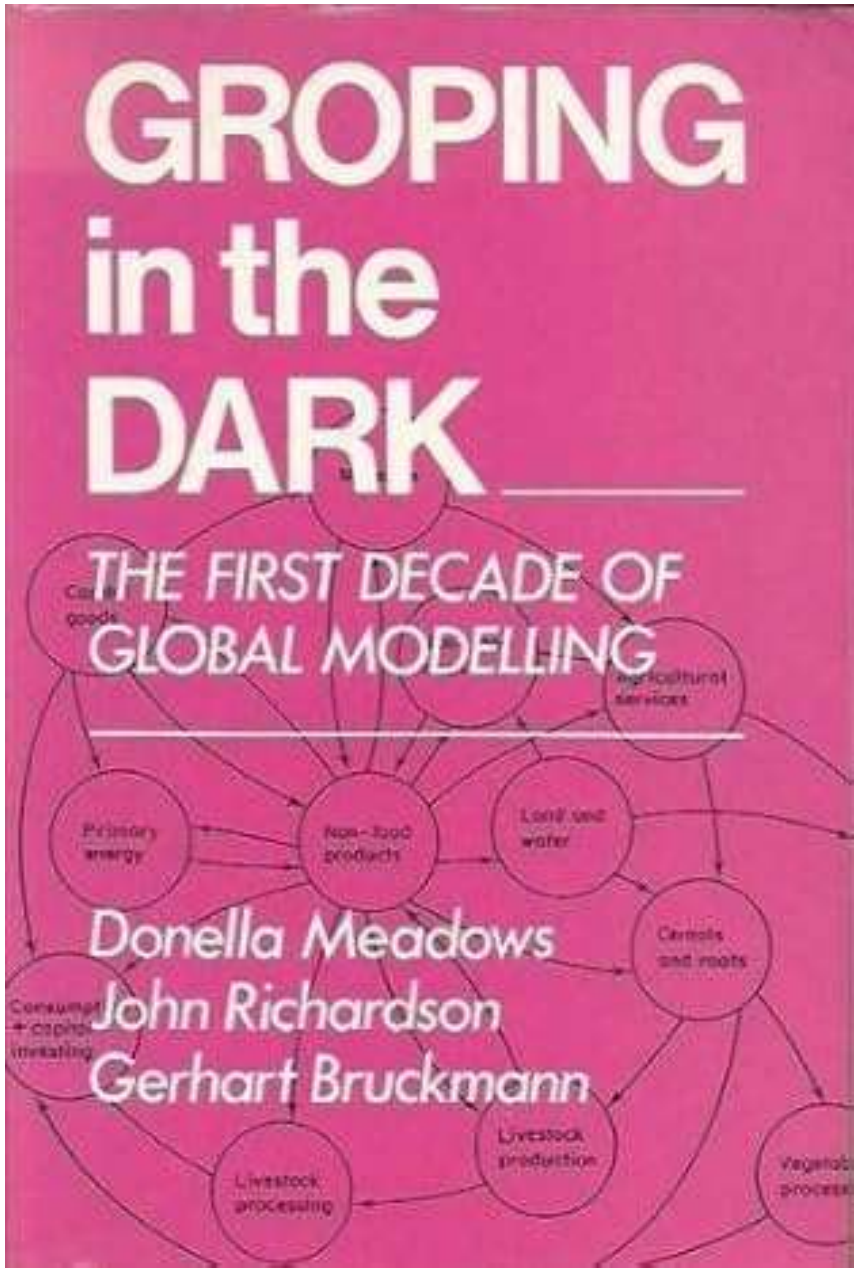
Jensen Huang the compute layer itself, NVIDIA's Earth-2 digital twin platform

The supply side of modelling

Vision 1 calls for many modest, local models — of a contaminated aquifer, a waste stream, a reef system, a fishery, an estuary

Vision 2 calls for integrated assessment models and digital twins, an ocean-climate twin. Computational ambition commands funding, prestige, and policy access

In the economy of modelling, scale itself becomes a source of epistemic authority



1982

These conversations had been had before to the effect that

The operational limits to humankind are sociopolitical and not physical

ELSEVIER

Futures

Volume 33, Issue 1, February 2001, Pages 77-89

The Latin American World Model (a.k.a. the Bariloche model): three decades ago

Gilberto C Gallopin

Show more

+ Add to Mendeley Share Cite

https://doi.org/10.1016/S0016-3287(00)00055-0

Get rights and content

An economy of promises

SPRINGER LINK

Log in

Find a journal | Publish with us | Search | Cart

Home > Sustainability Science > Article

The more things change, the more they stay the same: promises of bioeconomy and the economy of promises

Special Feature: Editorial | Open Access | Published: 23 March 2023 | 18, 557–568 (2023)

Sustainability Science

Aims and scope →

Submit manuscript →

Download PDF

You have full access to this open access article

Dennis Eversberg, Philip Koch, Rosa Lehmann, Andrea Saltelli, Sabaheta Ramcilovic-Suominen & Zora Kovacic

Use our pre-submission checklist →

Avoid common mistakes on your manuscript.

2247 Accesses 5 Citations 7 Altmetric Metrics Cite this article

Part of a collection:

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

Fantastic narratives of circular economy, geoengineering, rapid transitions & decarbonization just around the corner

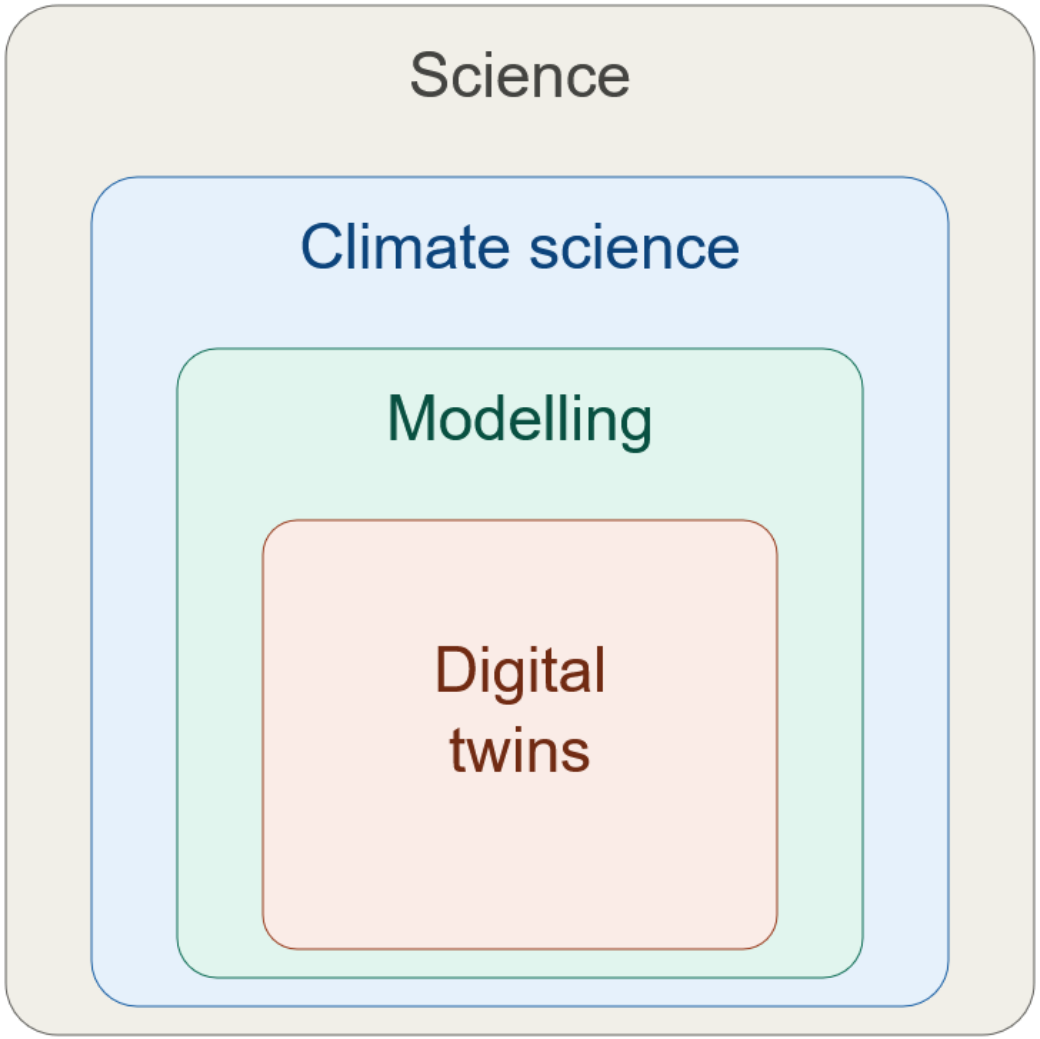
Giuseppe Tomasi di Lampedusa (1896-1957)

Migration of epistemic authority

The authority of science mediated through climate science

The authority of climate science mediated through modelling, and now the twins

➔The credibility of science is inseparable from the credibility of the models that sustain it



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

The ultimate modelling hubris: digital twins of the planet - EU Destination Earth

nature reviews earth & environment

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

3576 Accesses | 3 Citations | 27 Altmetric | Metrics

Cornell University

We gratefully acknowledge su

arXiv > physics > arXiv:2306.11175

Search...

Help | Adva

Physics > Physics and Society

[Submitted on 19 Jun 2023]

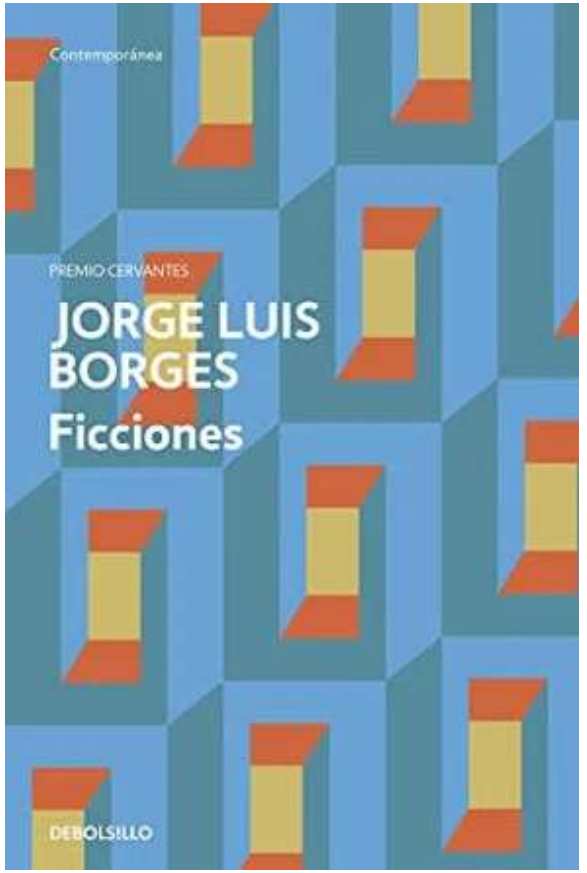
Developing Digital Twins for Earth Systems: Purpose, Requisites, and Benefits

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

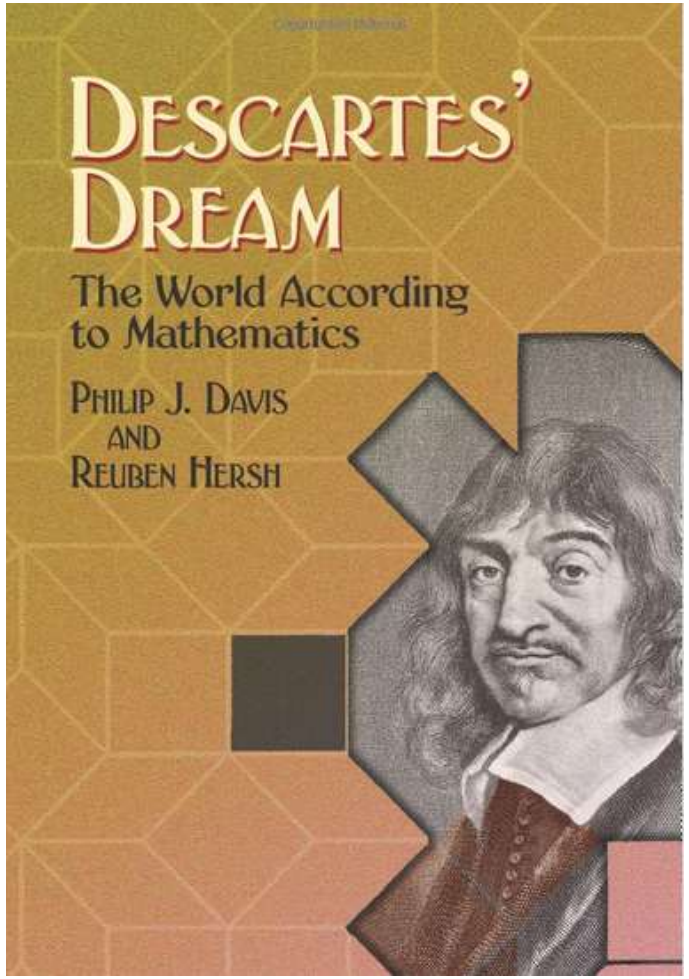
The accelerated change in our planet due to human activities has led to grand societal challenges including health crises, intensified extreme weather events, food security, environmental injustice, etc. Digital twin systems combined with emerging technologies such as artificial intelligence and edge 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.

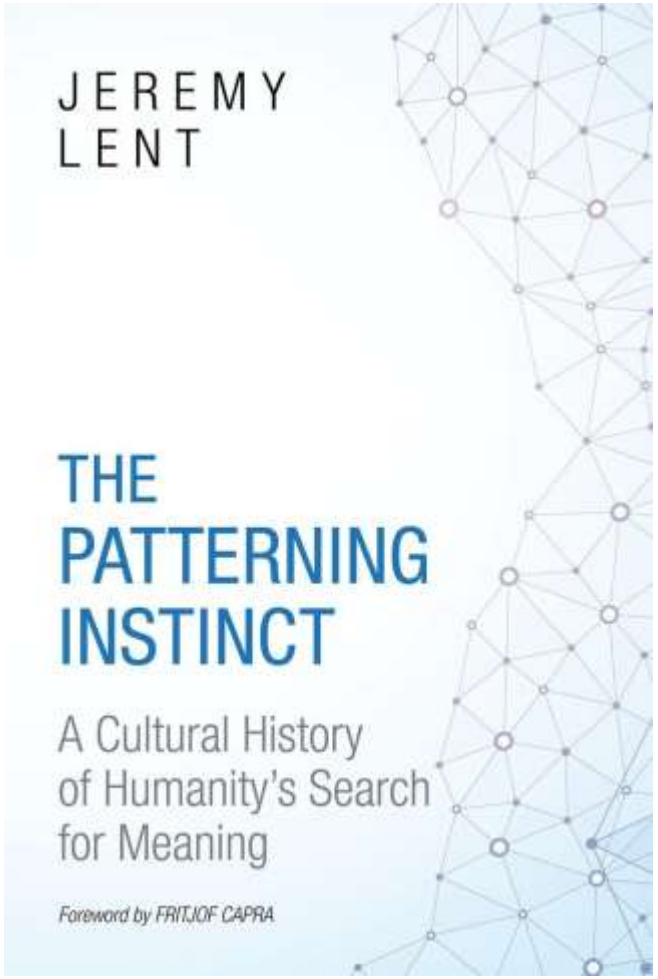
DT's as Jorge Luis Borges' (1946) one-to-one map of the empire

"In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City"



Digital Twins: The planet as a manufact = the Cartesian Dream; nature as machine (Jeremy Lent)





Jeremy Lent

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

DestinE is true game changer in our fight against climate change.”

- Margrethe Vestager -

"The launch of the initial Destination Earth (DestinE) is a true game changer in our fight against climate change," says Margrethe Vestager, Executive Vice-President for a Europe Fit for the Digital Age. "It means that we can observe environmental challenges which can help us predict future scenarios - like we have never done before... Today, the future is literally at our fingertips."

Margrethe Vestager

YOU CONTROL CLIMATE CHANGE.

www.climatechange.eu.com

TURN DOWN. SWITCH OFF. RECYCLE. WALK. CHANGE

The rhetoric of DestinE

WIREs CLIMATE CHANGE

RMetS Royal Geographical Society with IBG

Perspective | Open Access

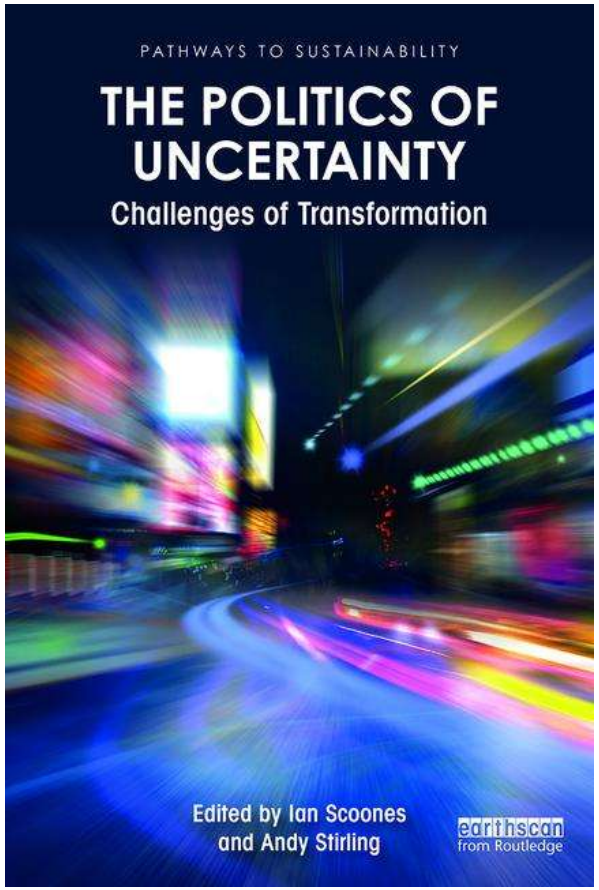
Bring digital twins back to Earth

Andrea Saltelli, Gerd Gigerenzer, Mike Hulme, Konstantinos V. Katsikopoulos, Lieke A. Melsen, Glen P. Peters, Roger Pielke Jr, Simon Robertson ... See all authors

First published: 26 August 2024 | https://doi.org/10.1002/wcc.915

"Climate intelligence"
"Decision-ready information" →
"Empowering citizens to become partners in knowledge generation" →
"Digital ecosystems," "data lakes," "digital species"

The EC leans toward technology as a conduit to solve policy problems ➔ European institutions are vulnerable to projects oriented to technological solutions and technological optimism



Chapter 4

THE UNRAVELLING OF TECHNOCRATIC ORTHODOXY?

Contemporary knowledge politics in technology regulation

Patrick van Zwanenbera

ACCESS

‘expected utility’, ‘decision theory’, ‘life cycle assessment’, ‘ecosystem services’ ‘sound scientific decisions’ and ‘evidence-based policy’ … profusion of digits, promises of accuracy

ELSEVIER

Research Policy

Available online 21 December 2022, 104709

In Press, Corrected Proof

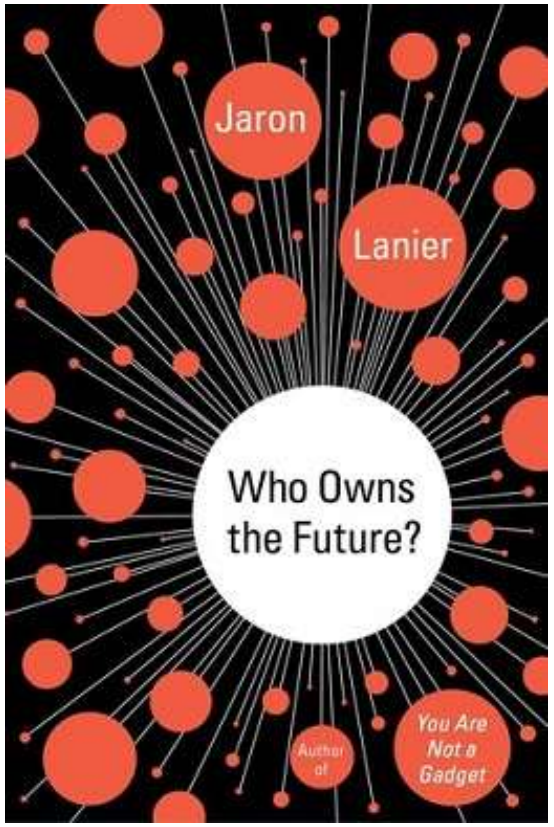
Discussion

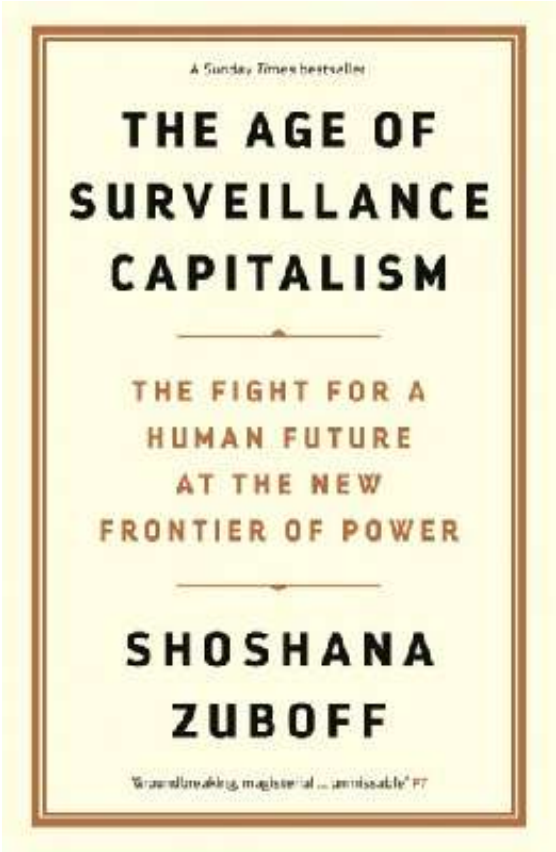
Against misleading technocratic precision in research evaluation and wider policy – A response to Franzoni and Stephan (2023), ‘uncertainty and risk-taking in science’

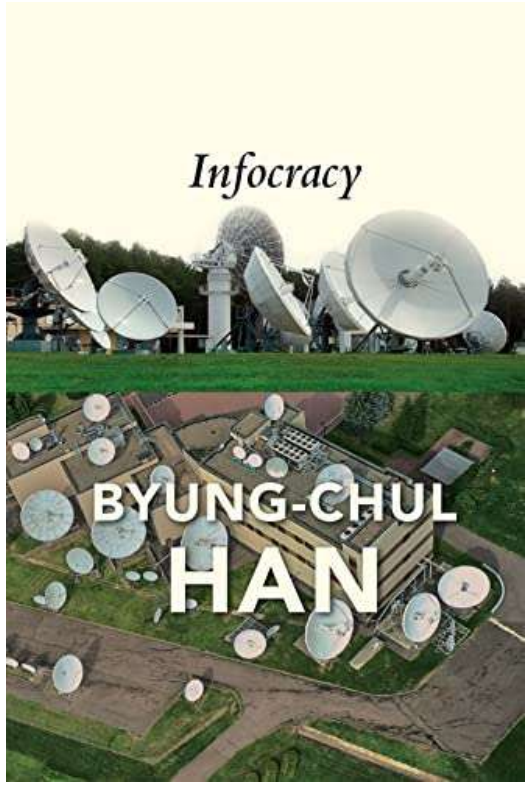
Andy Stirling

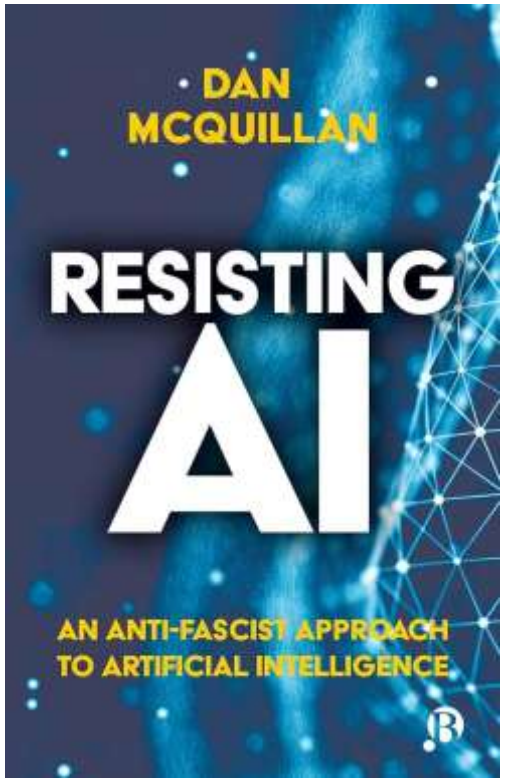
Andrew Stirling

The epistemic community around DestinE unconcerned about the digitalisation of the real









DT's are marketed as a source of 'climate intelligence' but if it is true that "Financial markets and private companies, are in an "arms race" for climate intelligence", should this race be met with public funds?

We have been there before

ELSEVIER

Energy Research & Social Science

Volume 127, September 2025, 104296

Original research article

Energy policy-making in the European Union between past and present ☆

Samuele Lo Piano [a b], Andrea Saltelli [b c]

Show more

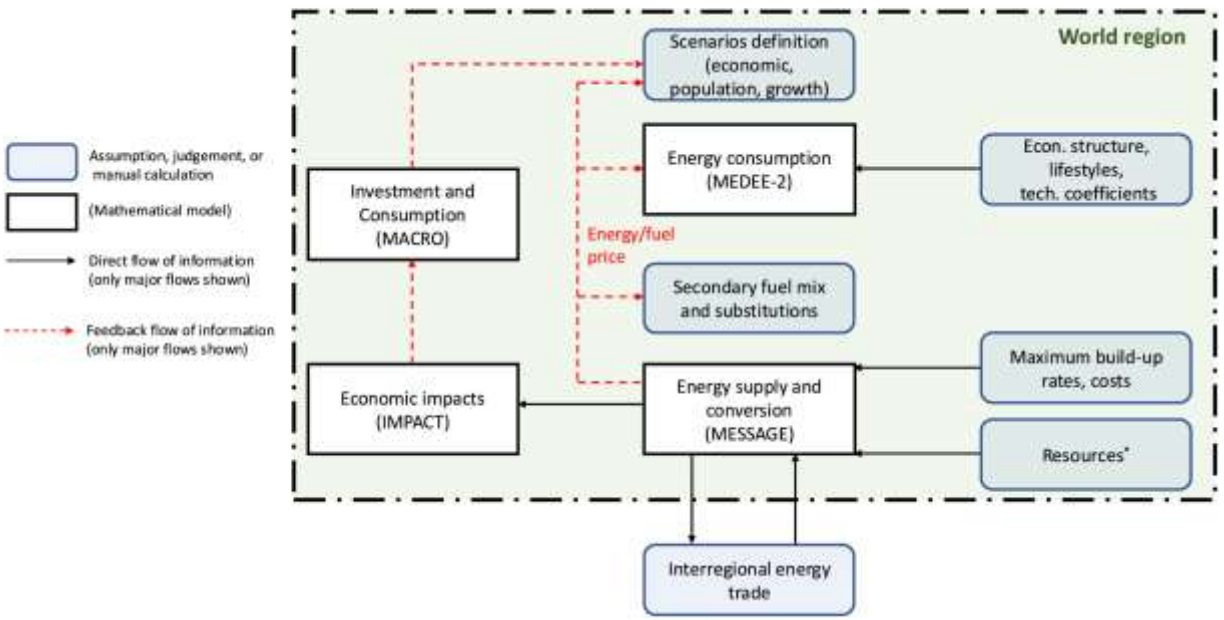
+ Add to Mendeley Share Cite

https://doi.org/10.1016/j.erss.2025.104296 ↗

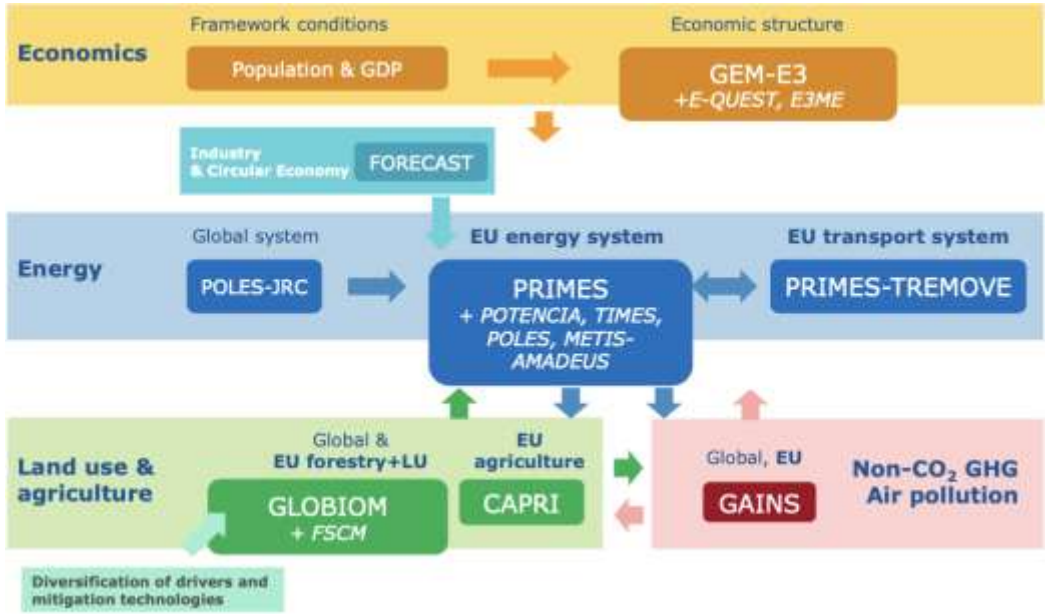
Get rights and content ↗

- We contrast a 1980s energy study and a 2024 EU impact assessment on emissions.
- Auditing reveals persistent flaws when models are used to inform policy.

IIASA 1980's



EC 2024



The rhetoric of the concatenated suite of models

Home › Policy Sciences › Article

The institutional context of science, models, and policy: The IIASA energy study

Published: September 1984

Volume 17, pages 277–320, (1984) Cite this article

The same way the Digital Twins of the planet are ‘scientifically prescribing’ today …

Brian Wynne (and others such as William Keepin) debunked in the early 80’s the 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

Risk Analysis
AN INTERNATIONAL JOURNAL
An Official Publication of the Society for Risk Analysis

PERSPECTIVE | Open Access

Unpacking the modeling process for energy policy making

Samuele Lo Piano, Máté János Lőrincz, Arnald Puy, Steve Pye, Andrea Saltelli, Stefán Thor Smith, Jeroen van der Sluijs

First published: 14 November 2023 | https://doi.org/10.1111/risa.14248

Computational colonialism

"Models of climate change seem at ease with a future in which existing levels of inequality are maintained" (Bhalla et al., 2023)

Kanitkar et al. (2024): across 556 IPCC AR6 mitigation scenarios, per-capita GDP in regions containing 60% of the world's population remains below the global average even in 2050

Is this tension relevant to DT of the ocean works?

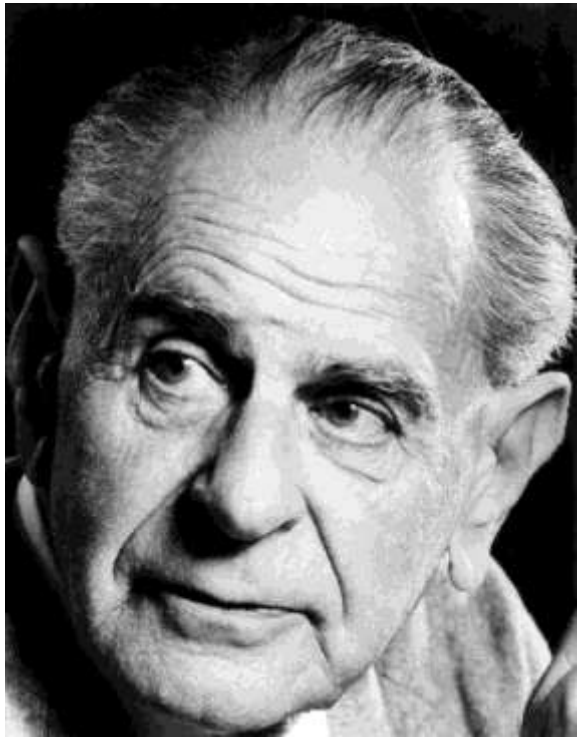
Models' and DTs' state of exception

- They resist falsification (projecting to 2100, 2300...)
- They are opaque (complexity exceeds reviewability)
- They are ritual and performative (they constitute the policy space)

Models that take no risks

The empirical content of a theory is measured by the risks it takes — the observations that could prove it wrong (severe tests)

Climate models projecting to 2300. Nuclear waste safety models covering a million years. Digital twins simulating ecosystem dynamics with 50-year horizons



Karl Popper
(1902–1994)

These models take no risks. No severe tests here

What would help

A model should not be used for policy unless:

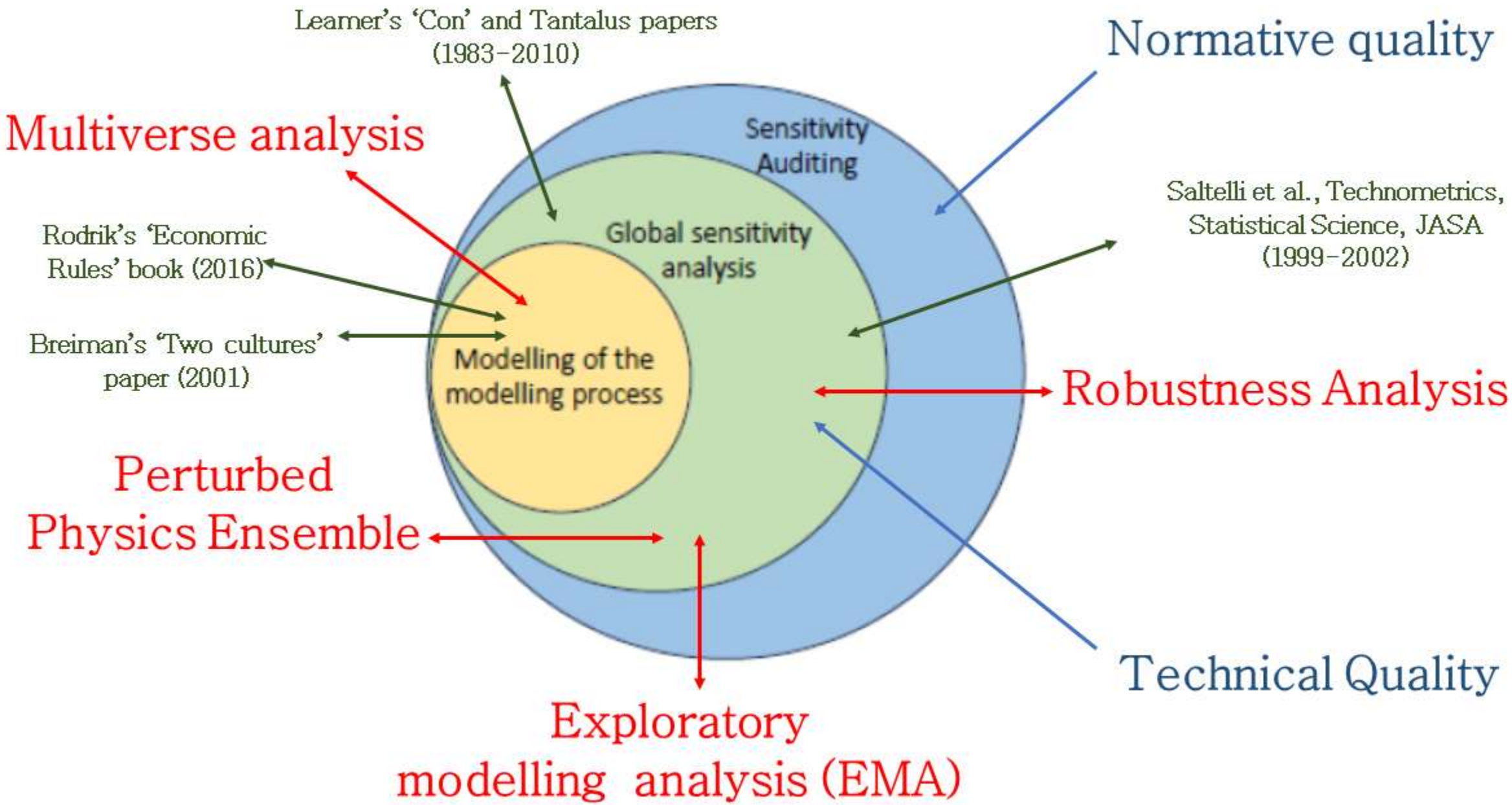
- Its **sensitivity** to key assumptions has been explored
- Its structural and **framing** choices have been made explicit and tested
- The **pedigree** of its data and parameters has been assessed
- **Affected parties** have had the opportunity to identify which assumptions matter to them

Global sensitivity analysis

Modelling of the modelling process

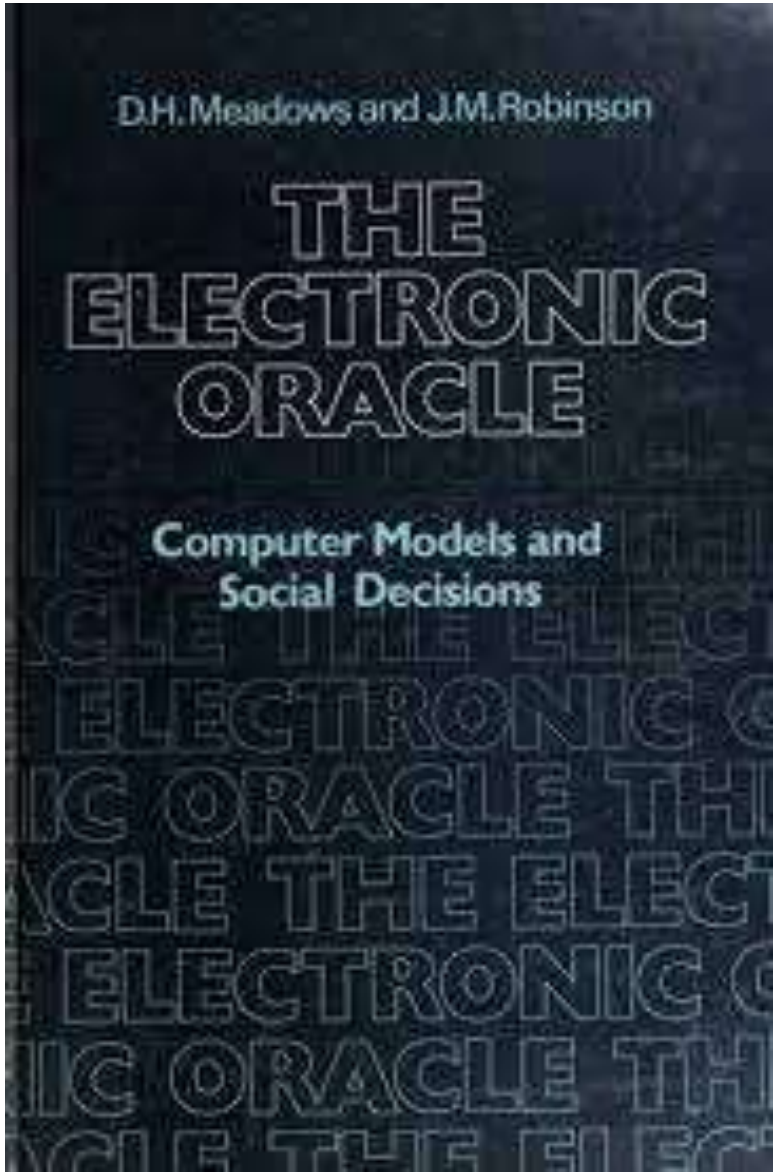
NUSAP

Sensitivity auditing


Learner's 'Con' and Tantalus papers (1983–2010)
Normative quality
Multiverse analysis
Sensitivity Auditing
Global sensitivity analysis
Modelling of the modelling process
Saltelli et al., Technometrics, Statistical Science, JASA (1999–2002)
Rodrik's 'Economic Rules' book (2016)
Breiman's 'Two cultures' paper (2001)
Robustness Analysis
Perturbed Physics Ensemble
Technical Quality
Exploratory modelling analysis (EMA)

All of the above has historically lacked traction… Why?

- Supply-side incentives (models produced for career, not policy needs)
- Conspicuous cognition (allegiance to complexity as cultural marker)
- Institutional lock-in (modelling infrastructures create constituencies)
- Absence of institutional demand (politicians like models' neutrality)



Published in 1985

Alternatives: Statactivism and counter-modelling

- Statactivists: societal mobilisation around alternative numbers
- Countermodelling: building models that respond to different framings
- Critical friends: engaging with modelling communities from within
- Observatories: permanent watchdog institutions

The reformation question: Can the relationship between science and society — mediated by models — be renegotiated?

Three possibilities:

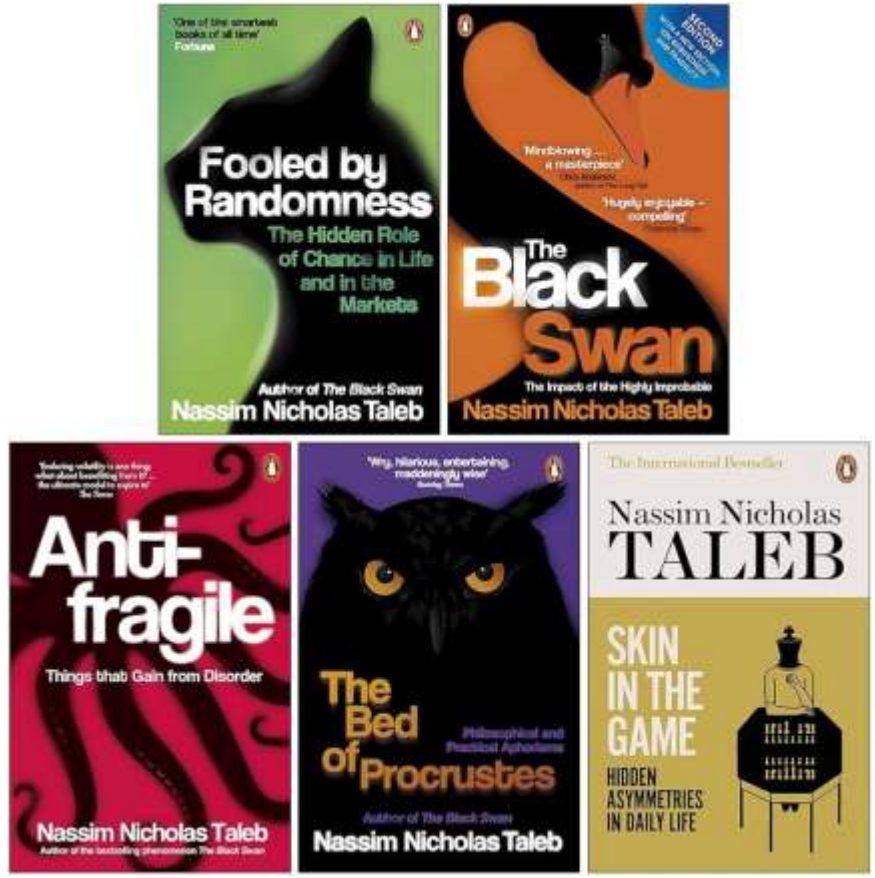
1. A renegotiation is possible through institutional reform

A better number is possible

The reformation question: Can the relationship between science and society — mediated by models — be renegotiated?

2. *Via negativa*: we cannot say what good model governance looks like, but we can say what it must not be

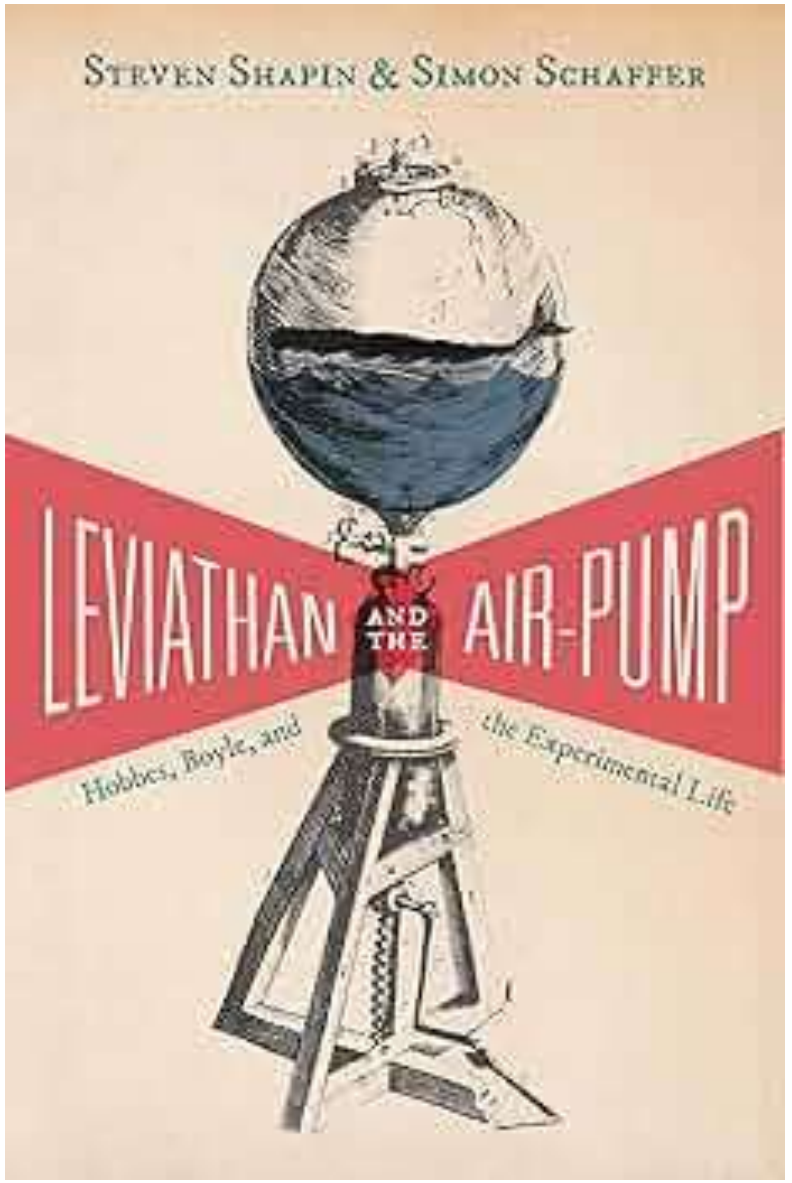
Via negativa →



The reformation question: Can the relationship between science and society — mediated by models — be renegotiated?

3. Reformation: a radically different relation between science and policy

Solutions to the problem of knowledge are solutions to the problem of social order →



Books

•Beck, U. (1992). *Risk Society: Towards a New Modernity*. Sage.
•Davis, P.J. & Hersh, R. (1986). *Descartes' Dream: The World According to Mathematics*. Harcourt.
•Edwards, P.N. (2010). *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. MIT Press.
•Hajer, M.A. & Oomen, J. (2022). *Captured Futures: Rethinking the Drama of Environmental Politics*. Oxford University Press.
•Hulme, M. (2023). *Climate Change Isn't Everything*. Polity Press.
•Lanier, J. (2013). *Who Owns the Future?* Simon & Schuster.
•Lent, J. (2017). *The Patterning Instinct: A Cultural History of Humanity's Search for Meaning*. Prometheus Books.
•McQuillan, D. (2022). *Resisting AI: An Anti-Fascist Approach to Artificial Intelligence*. Bristol University Press.
•Meadows, D.H. & Robinson, J.M. (1985). *The Electronic Oracle: Computer Models and Social Decisions*. Wiley.
•Meadows, D.H., Richardson, J. & Bruckmann, G. (1982). *Groping in the Dark: The First Decade of Global Modelling*. Wiley.
•Saltelli, A. & Di Fiore, M. (Eds.) (2023). *The Politics of Modelling: Numbers Between Science and Policy*. Oxford University Press.
•Saltelli, A. (2026). *Equations of Power: Models, Authority, and the Politics of Knowledge*. Anthem Press, to appear.
•Shapin, S. & Schaffer, S. (1985). *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton University Press.
•Taleb, N.N. *Fooled by Randomness*. Random House.
•Taleb, N.N. *The Black Swan*. Random House.
•Taleb, N.N. *Antifragile*. Random House.
•Taleb, N.N. *The Bed of Procrustes*. Random House.
•Taleb, N.N. *Skin in the Game*. Random House.
•Toulmin, S. (1990). *Cosmopolis: The Hidden Agenda of Modernity*. University of Chicago Press.
•Zuboff, S. (2019). *The Age of Surveillance Capitalism*. PublicAffairs.
•Han, B-C. (2022). *Infocracy*. Polity Press.
•Bruno, I., Didier, E. & Prévieux, J. (Eds.) (2014). *Statactivisme*. Zones.

Book chapter

•van Zwanenberg, P. (2024). The unravelling of technocratic orthodoxy? Contemporary knowledge politics in technology regulation. In I. Scoones & A. Stirling (Eds.), *The Politics of Uncertainty: Challenges of Transformation*. Earthscan/Routledge.

Journal articles

•Bauer, P., Stevens, B. & Hazeleger, W. (2021). A digital twin of Earth for the green transition. *Nature Climate Change*, 11, 80–83.
•Bhalla, J. (2023, February 4). We can't have climate justice without ending computational colonialism. *Current Affairs*. https://www.currentaffairs.org/news/2023/02/we-cant-have-climate-justice-without-ending-computational-colonialism
•Eversberg, D., Koch, P., Lehmann, R., Saltelli, A., Ramcilovic-Suominen, S. & Kovacic, Z. (2023). The more things change, the more they stay the same: promises of bioeconomy and the economy of promises. *Sustainability Science*, 18, 557–568.
•Gallopin, G.C. (2001). The Latin American World Model (a.k.a. the Bariloche model): three decades ago. *Futures*, 33(1), 77–89.
•Kanitkar, T., Mythri, A. & Jayaraman, T. (2024). Equity assessment of global mitigation pathways in the IPCC Sixth Assessment Report. *Climate Policy*, 24(8), 1129–1148.
•Li, X. et al. (2023). Big data in Earth system science and progress towards a digital twin. *Nature Reviews Earth & Environment*, 4, 319–332.
•Lo Piano, S. & Saltelli, A. (2025). Energy policy-making in the European Union between past and present. *Energy Research & Social Science*, 127, 104296.
•Lo Piano, S., Lőrincz, M.J., Puy, A., Pye, S., Saltelli, A., Thor Smith, S. & van der Sluijs, J. (2023). Unpacking the modeling process for energy policy making. *Risk Analysis*. https://doi.org/10.1111/risa.14248
•Marres, N. (2018). Why we can't have our facts back. *Engaging Science, Technology, and Society*, 4, 423–443.
•Mills, M.A. & St. Clair, P. (2025). The strange new politics of science. *Issues in Science and Technology*, XLI(3).
•Rao, Y. et al. (2023). Developing digital twins for Earth systems: purpose, requisites, and benefits. *arXiv*:2306.11175.
•Saltelli, A., Puy, A. & Di Fiore, M. (2024). Mathematical models: a state of exception. *International Review of Applied Economics*, 39(6), 862–879.
•Saltelli, A., Gigerenzer, G., Hulme, M., Katsikopoulos, K.V., Melsen, L.A., Peters, G.P., Pielke Jr., R., Robertson, S. et al. (2024). Bring digital twins back to Earth. *WIREs Climate Change*. https://doi.org/10.1002/wcc.915
•Stirling, A. (2022). Against misleading technocratic precision in research evaluation and wider policy. *Research Policy*, 104709.
•Westerlaken, M. (2024). Digital twins and the digital logics of biodiversity. *Social Studies of Science*, 54(4).
•Williams, D. (2025, October 26). On highbrow misinformation. *Conspicuous Cognition*. https://www.conspicuouscognition.com/
•Wynne, B. (1984). The institutional context of science, models, and policy: the IIASA energy study. *Policy Sciences*, 17, 277–320.

END