

Sensitivity Auditing

Andrea Saltelli

June 2023

Statistical Data Analysis Module A

&

Project i4Driving



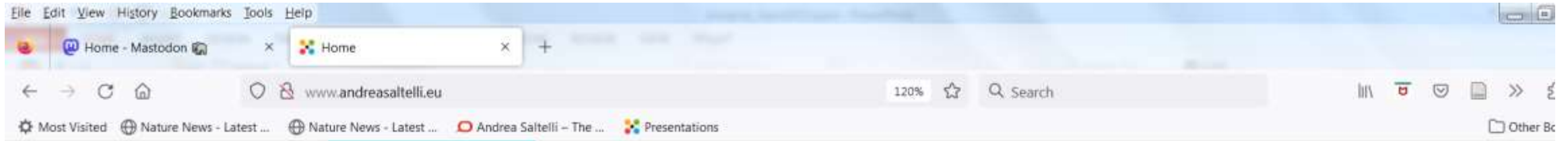
**Integrated 4D driver
modelling under
uncertainty**

Project started on October 1st, 2022

i4Driving

a EU Horizon Europe R&I project

Where to find this talk: www.andreasaltelli.eu



HOME ABOUT ME PUBLICATIONS NEWS & VIDEOS RESOURCES

Coming Out Soon: The politics of modelling



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

Mastodon Toots by

@AndreaSaltelli



AndreaSaltelli

2023/4/18 17:24

"Kaufman, who was until recently a senior climate economist in the White House, questioned the need for the government to set a single price. Regulators should stop "pretending we

Uncertainty analysis: the study of the uncertainty in model output—see also uncertainty cascade

Sensitivity analysis: the study of the relative importance of different input factors on the model output

Sensitivity auditing : “Sensitivity auditing is a wider consideration of the effect of all types of uncertainty, including structural assumptions embedded in the model, and subjective decisions taken in the framing of the problem” (European Commission, 2021).

There are technical as well as
normative reasons for engaging in
sensitivity auditing; we look at the
technical reasons first

Fishing expeditions, forking paths ...



Fishing Boats at Sea, Vincent van Gogh, Pushkin Museum, Moscow, Russia



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

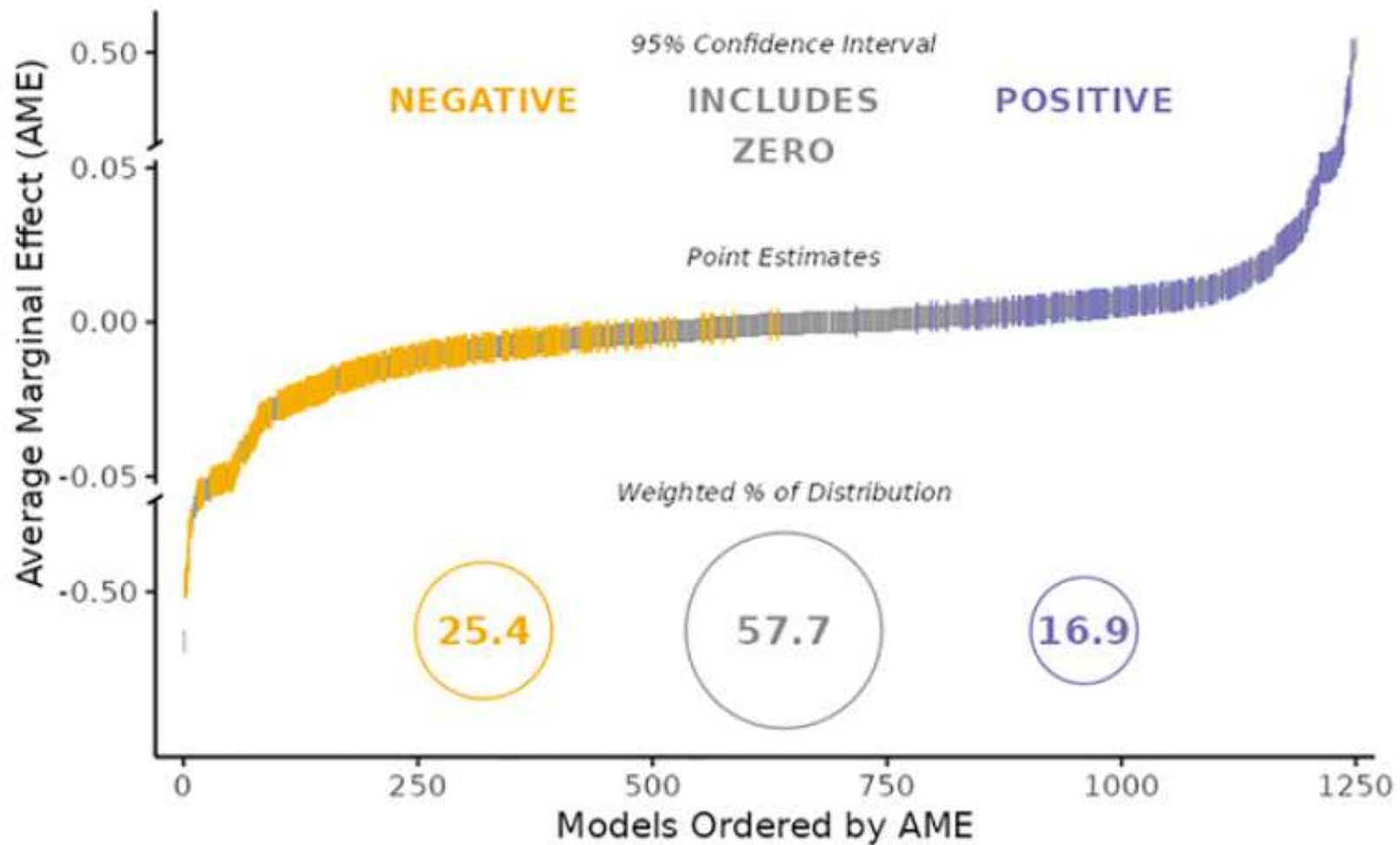
RESEARCH ARTICLE

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)

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

Modellers might (even in good faith) engage in “fishing expeditions”


When they do, they may delude themselves with having nailed an effect ...

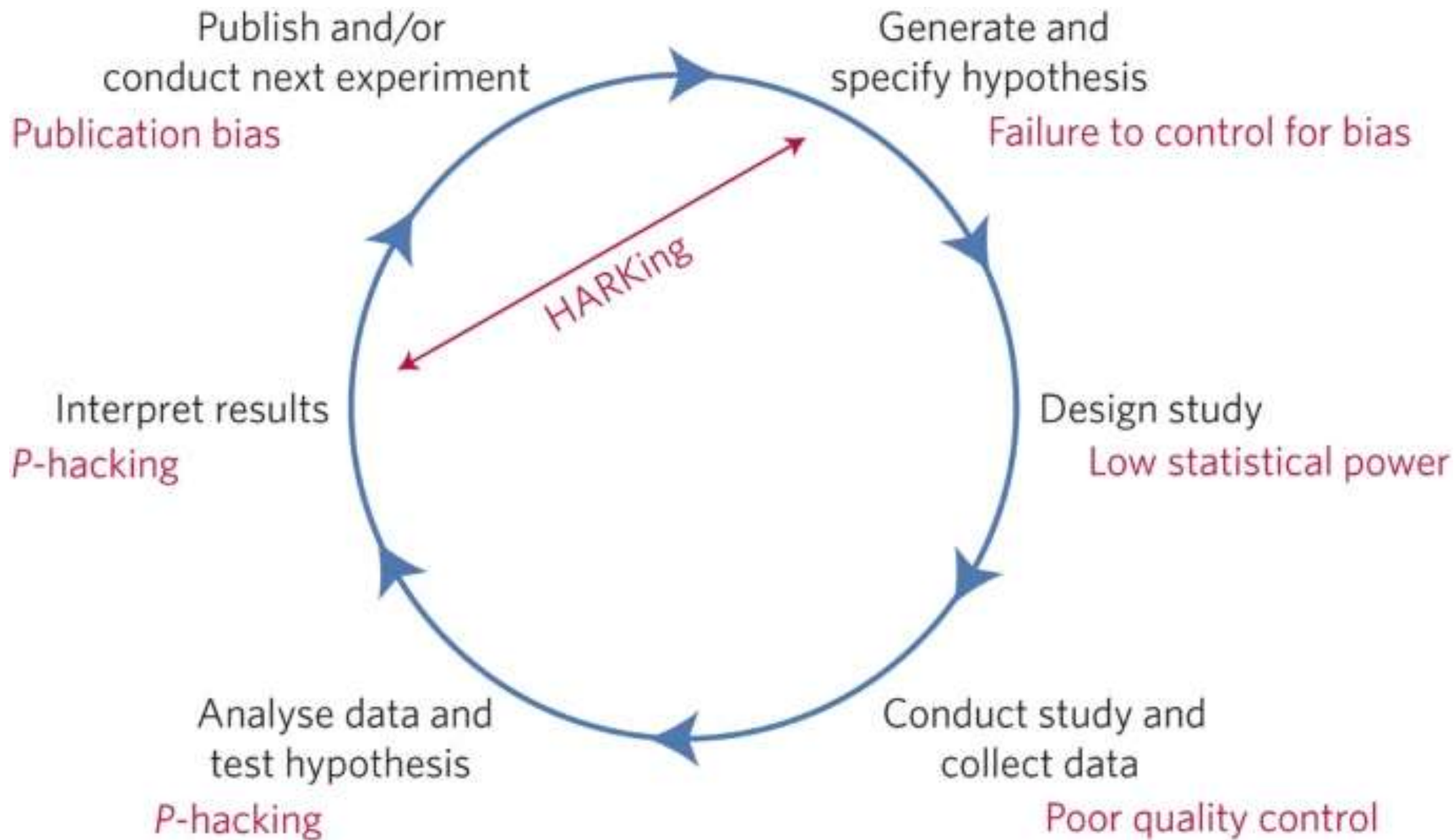
...as there are many things that may go wrong (or generate forks in the path)

nature human behaviour

Open Access | Published: 10 January 2017

A manifesto for reproducible science

Marcus R. Munafò , Brian A. Nosek, Dorothy V. M. Bishop, Katherine S. Button, Christopher D. Chambers, Nathalie Percie du Sert, Uri Simonsohn, Eric-Jan Wagenmakers, Jennifer J. Ware & John P. A. Ioannidis



Since having one's model replicated by 73 teams is impractical, one needs to check the inference, for example with sensitivity auditing and its modelling of the modelling process

nature

[Explore content](#) ▾ [Journal information](#) ▾ [Publish with us](#) ▾

[nature](#) > [comment](#) > [article](#)

COMMENT | 24 June 2020

Five ways to ensure that models serve society: a manifesto





Futures

Volume 144, December 2022, 103041



Unpacking the modelling process via sensitivity auditing

[Samuele Lo Piano](#)^a  , [Razi Sheikholeslami](#)^b, [Arnald Puy](#)^{c d e}, [Andrea Saltelli](#)^f

[Show more](#) ▾

Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

Complexity can be the enemy of relevance

Mind the framing

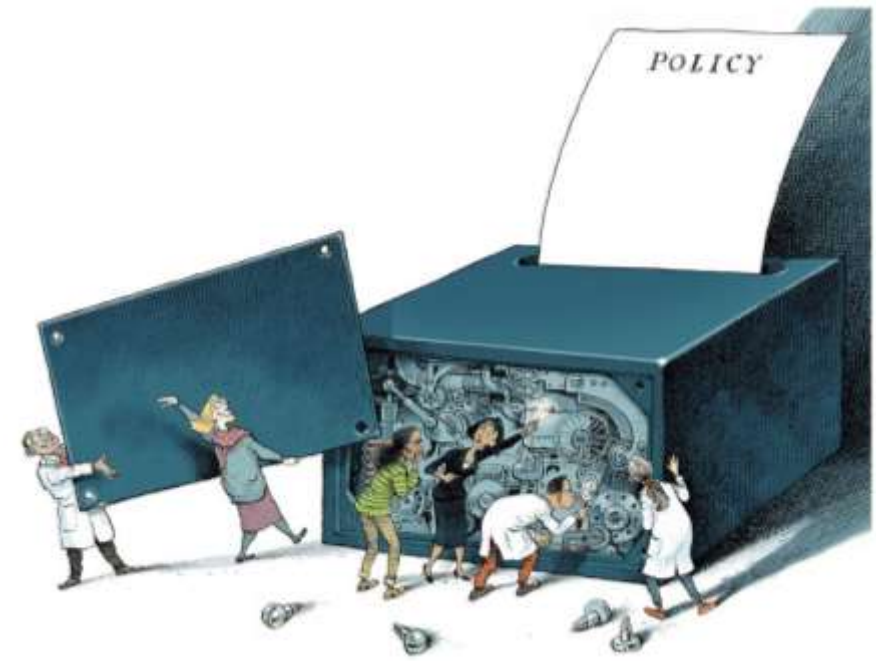
Match purpose and context

Mind the consequences

Quantification can backfire.

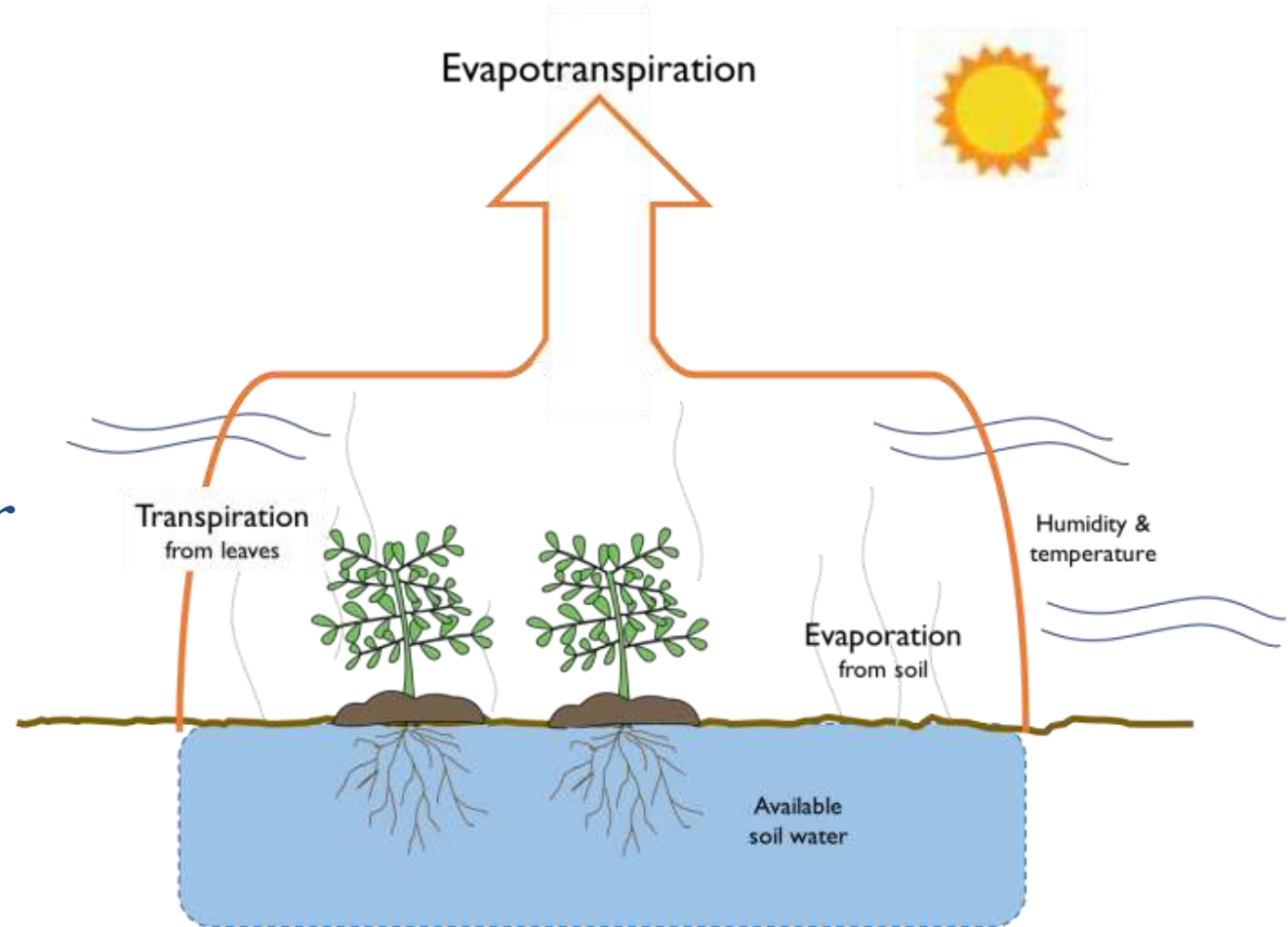
Mind the unknowns

Acknowledge ignorance



If several formulas / conceptualizations are available for a given phenomenon, use them all

An example: different equations are available for evapotranspiration



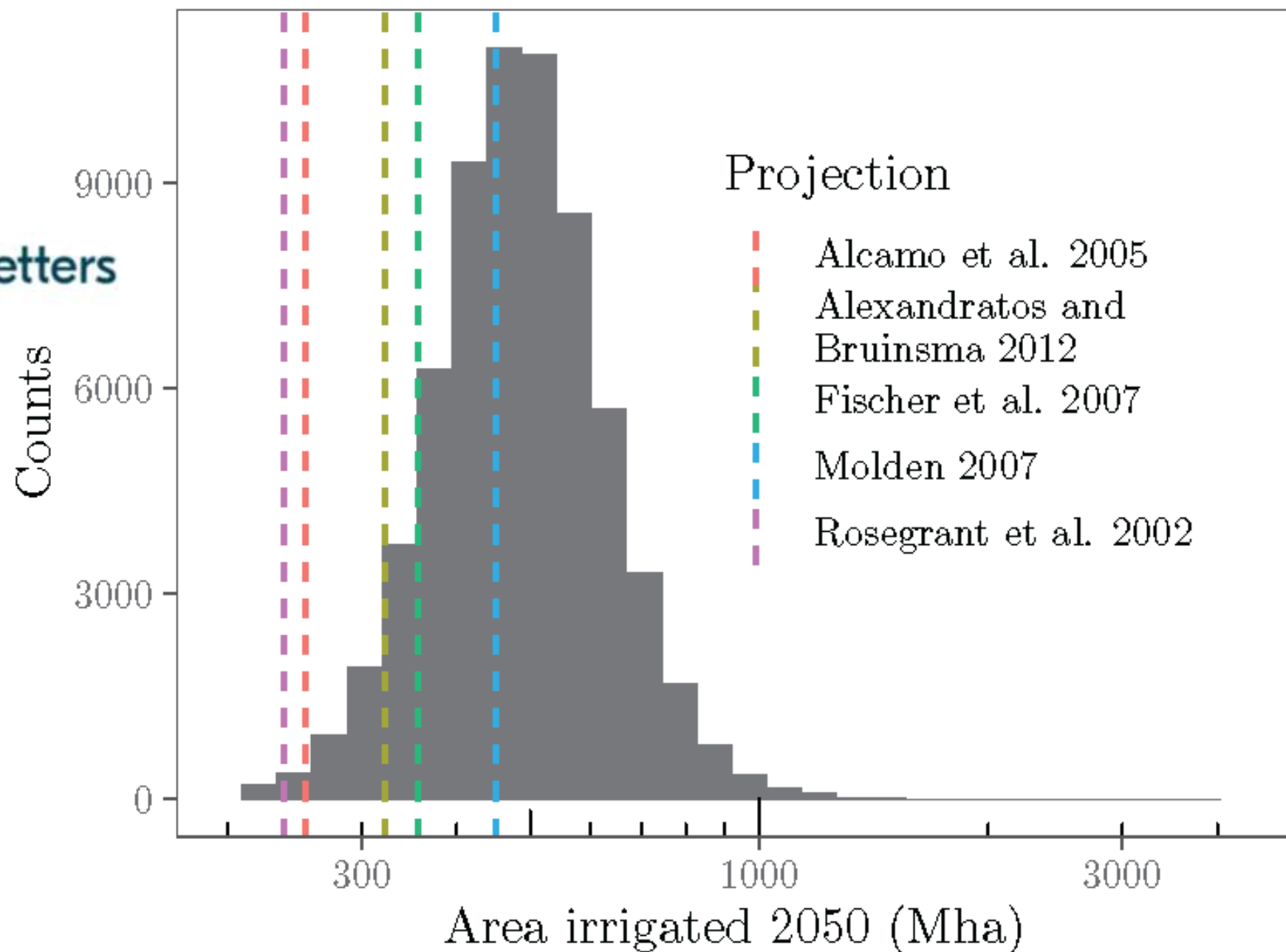
Current Models Underestimate Future Irrigated Areas

Geophysical Research Letters

A. Puy✉, S. Lo Piano, A. Saltelli

Citation:

Puy, A., Lo Piano, S., & Saltelli, A. (2020). Current models underestimate future irrigated areas. *Geophysical Research Letters*, 47, e2020GL087360. <https://doi.org/10.1029/2020GL087360>



Normative reasons for engaging with sensitivity auditing

Mind the assumptions

Assess uncertainty and sensitivity

Mind the hubris

Complexity can be the enemy of relevance

Mind the framing

Match purpose and context

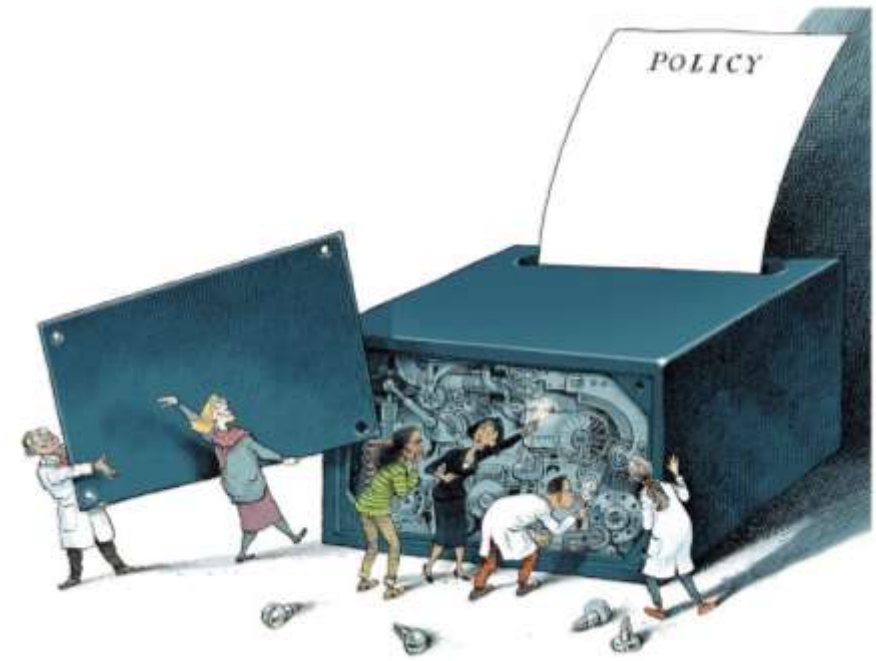


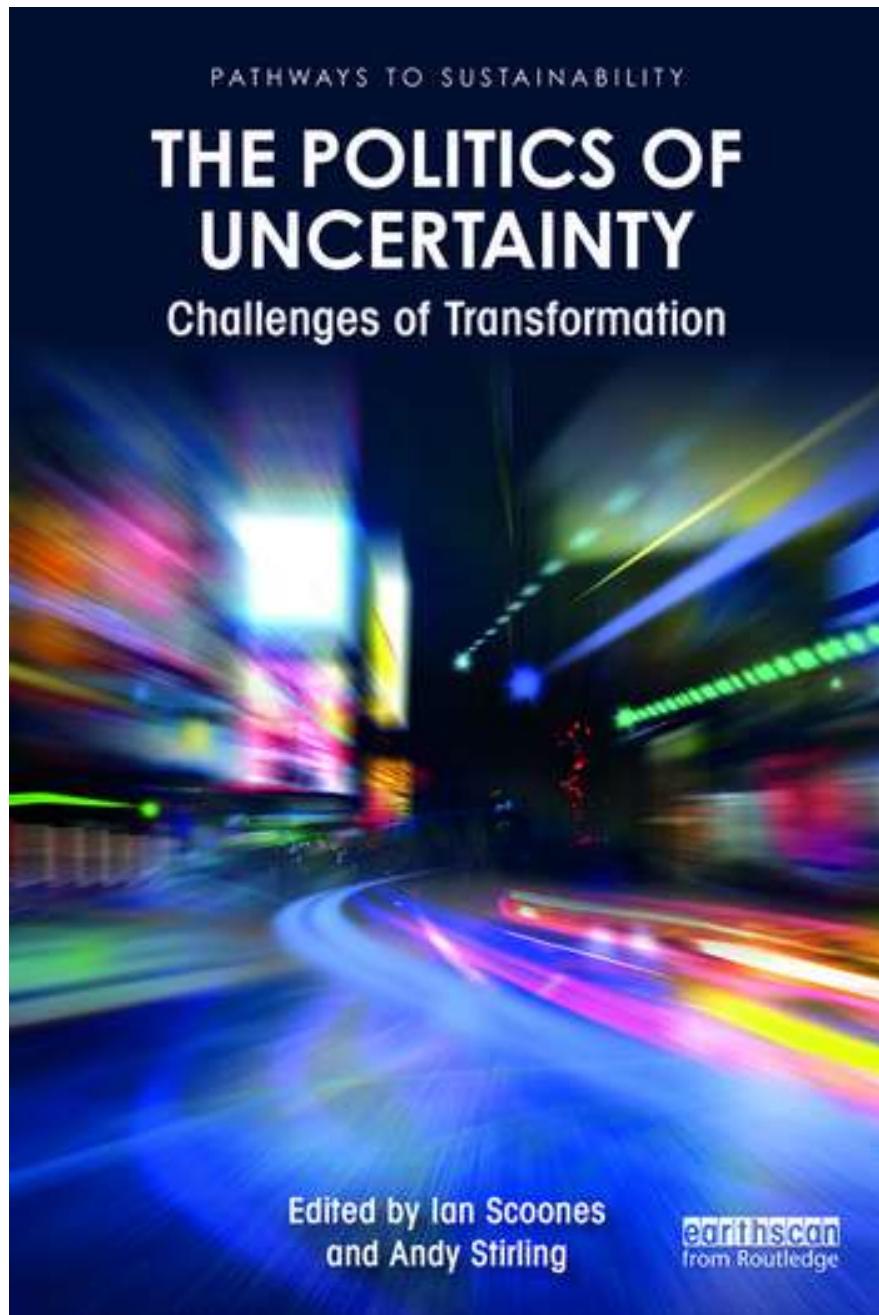
Mind the consequences

Quantification can backfire.

Mind the unknowns

Acknowledge ignorance





3

SHARING RISKS OR PROLIFERATING UNCERTAINTIES?

Insurance, disaster and development

Leigh Johnson

Model-based parametric insurance led to dramatic consequences for developing countries experiencing draughts

Open access: <https://www.taylorfrancis.com/books/politics-uncertainty-ian-scoones-andy-stirling/e/10.4324/9781003023845>

[« Back to Article](#)

WIRED MAGAZINE: 17.03

Recipe for Disaster: The Formula That Killed Wall Street

By Felix Salmon 02.23.09



$$\Pr[T_A < 1, T_B < 1] = \Phi_2(\Phi^{-1}(F_A(1)), \Phi^{-1}(F_B(1)), \gamma)$$

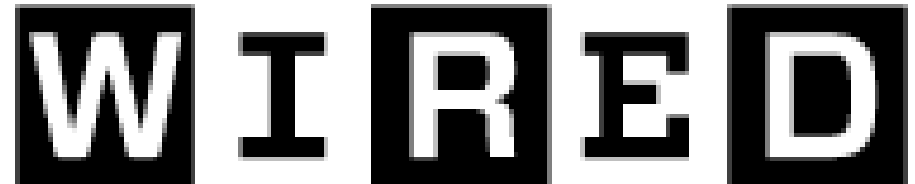
Here's what killed your 401(k) *David X. Li's Gaussian copula function as first published in 2000. Investors exploited it as a quick—and fatally flawed—way to assess risk. A shorter version appears on this month's cover of Wired.*

Here is what killed your 401(k)...

Li's Gaussian copula function ...

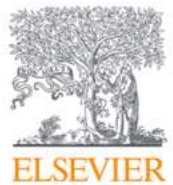
Nassim Nicholas Taleb, hedge fund manager and author of *The Black Swan*, is particularly harsh when it comes to the copula. "People got very excited about the Gaussian copula because of its mathematical elegance, but the thing never worked," he says. "Co-association between securities is not measurable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

Felix Salmon, Wired, February 2009



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

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



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

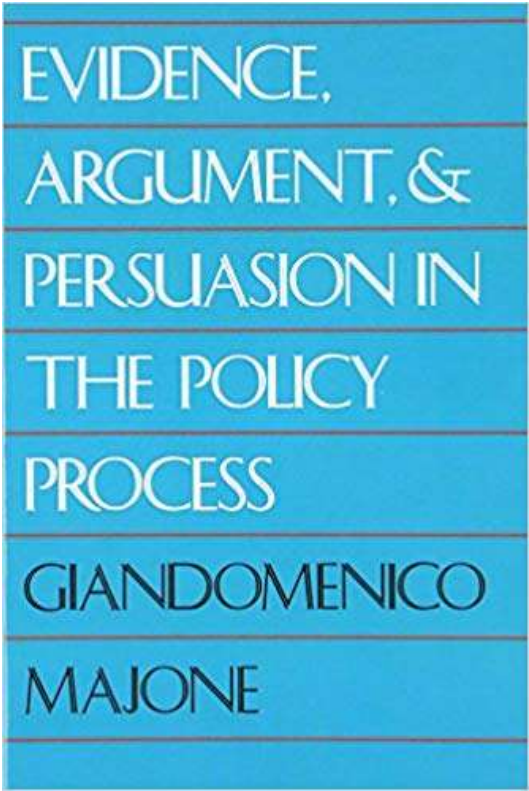


Andrew Stirling

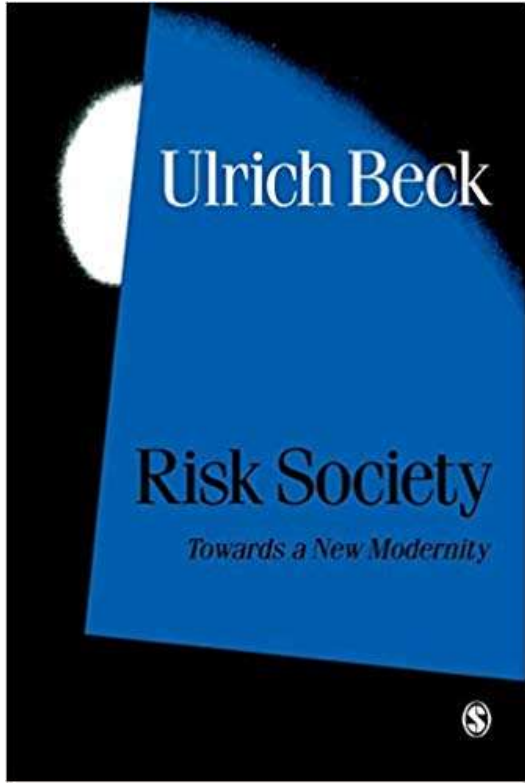
From Ulrich Beck to Giandomenico Majone: the technique is never neutral



Ulrich Beck
(1944 –2015)



1989



1992 (1986)



Environmental Science & Policy

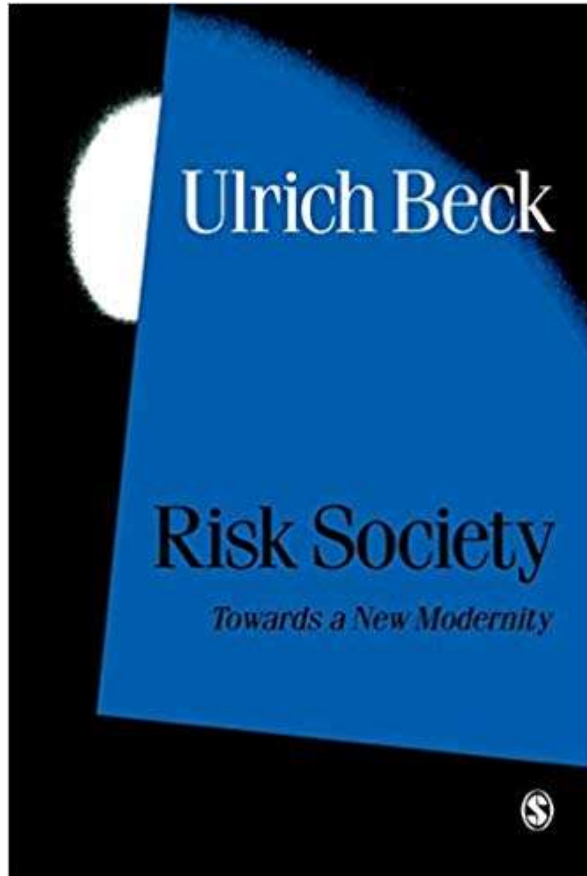
Volume 106, April 2020, Pages 87-98



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

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

“It is not uncommon for political programs to be decided in advance simply by the choice of what **model is chosen**”



1992 (1986)



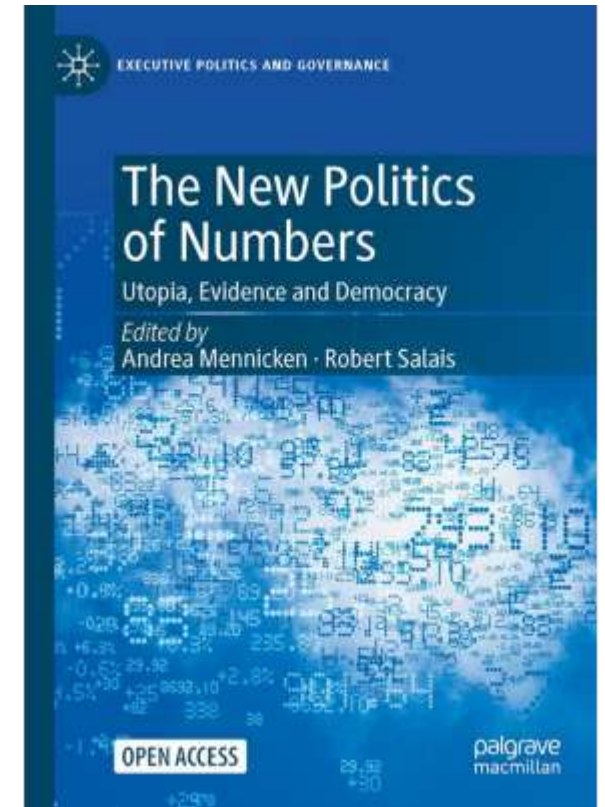
Ulrich Beck
(1944 –2015)

Since the technique is never neutral a technical proof of quality is illusory without a parallel investigation of normative quality

Technical Quality

Normative quality

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. In *The New Politics of Numbers: Utopia, Evidence and Democracy*, Andrea Mennicken and Robert Salais, Palgrave Macmillan, pp. 379–415.



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](#)

448 Accesses | 4 Altmetric | [Metrics](#)

Technical Quality

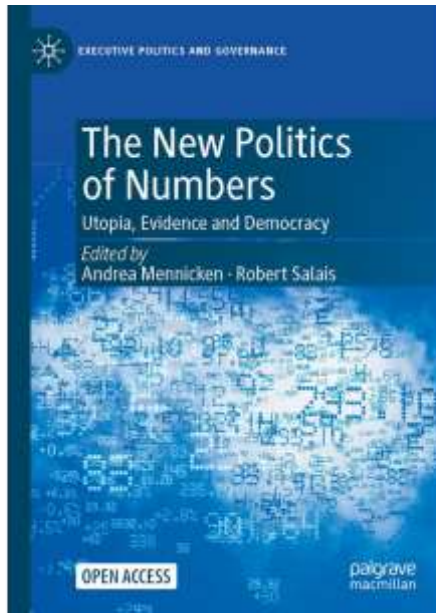


Sensitivity analysis

Normative quality



Sensitivity auditing



Reading material

Beck, P U. 1992. Risk Society: Towards a New Modernity. Published in Association with Theory, Culture & Society. Sage Publications (CA).

Breznau, Nate, Eike Mark Rinke, Alexander Wuttke, Hung H. V. Nguyen, Muna Adem, Jule Adriaans, Amalia Alvarez-Benjumea, et al. 2022. “Observing Many Researchers Using the Same Data and Hypothesis Reveals a Hidden Universe of Uncertainty.” Proceedings of the National Academy of Sciences 119 (44): e2203150119. <https://doi.org/10.1073/pnas.2203150119>.

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

Gelman, Andrew, and Eric Loken. 2013. “The Garden of Forking Paths.” Working Paper Department of Statistics, Columbia University. http://www.stat.columbia.edu/~gelman/research/unpublished/p_hacking.pdf.

Lo Piano, Samuele, Razi Sheikholeslami, Arnald Puy, and Andrea Saltelli. 2022. “Unpacking the Modelling Process via Sensitivity Auditing.” Futures, September, 103041. <https://doi.org/10.1016/j.futures.2022.103041>.

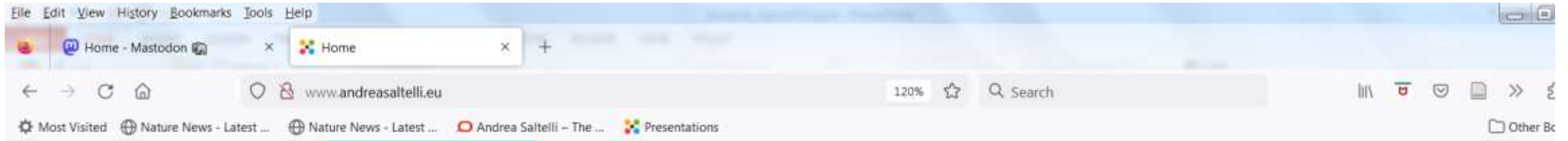
Puy, Arnald, Razi Sheikholeslami, Hoshin Gupta, Jim W. Hall, Bruce Lankford, Samuele Lo Piano, J Meier, et al. 2022. “The Delusive Accuracy of Global Irrigation Water Withdrawal Estimates.” Nature Communications 13 (3183).

Salais, Robert. 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 Rober Salais, 379–415. : : Utopia, Evidence and Democracy. Palgrave Macmillan.

Saltelli, Andrea, Gabriele Bammer, Isabelle Bruno, Erica Charters, Monica Di Fiore, Emmanuel Didier, Wendy Nelson Espeland, et al. 2020. “Five Ways to Ensure That Models Serve Society: A Manifesto.” Nature 582: 482–84.

Saltelli, Andrea, Lorenzo Benini, Silvio Funtowicz, M. Giampietro, Matthias Kaiser, Erik S. Reinert, and Jeroen P. van der Sluijs. 2020. “The Technique Is Never Neutral. How Methodological Choices Condition the Generation of Narratives for Sustainability.” Environmental Science and Policy 106: 87–98.

More material at www.andreasaltelli.eu



HOME ABOUT ME PUBLICATIONS NEWS & VIDEOS RESOURCES

Coming Out Soon: The politics of modelling



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

Mastodon Toots by

@AndreaSaltelli



AndreaSaltelli

2023/4/18 17:24

"Kaufman, who was until recently a senior climate economist in the White House, questioned the need for the government to set a single price. Regulators should stop "pretending we