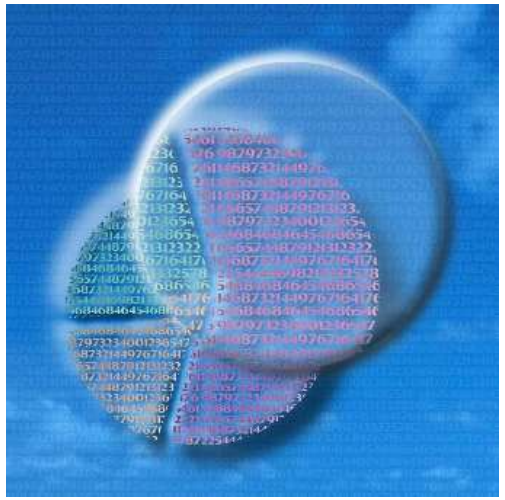

No demographic projection is ever neutral

Samuele Lo Piano[a], Marta Kuc-Czarnecka[a], and Andrea Saltelli[b,c]

(a) Department of Statistics and Econometrics, Faculty of Management and Economics, Gdańsk University of Technology, Gdańsk, Poland
(b) University Pompeu Fabra, Barcelona School of Management, Barcelona, Spain
(c) Centre for the Study of the Sciences and the Humanities, University of Bergen, Norway

Abstract 1216, RS 2.1.1: Welfare states, fiscal policy, and taxation. Time: Wednesday, 25/June: 11:00am - 12:30pm

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Where to find this talk: www.andreasaltelli.eu

Andrea Saltelli

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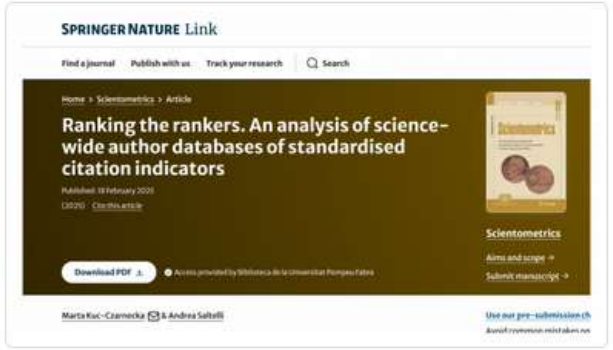
Latest papers



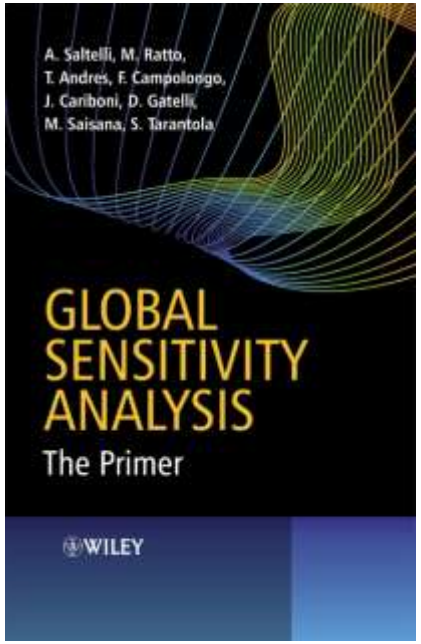
Models and the common good

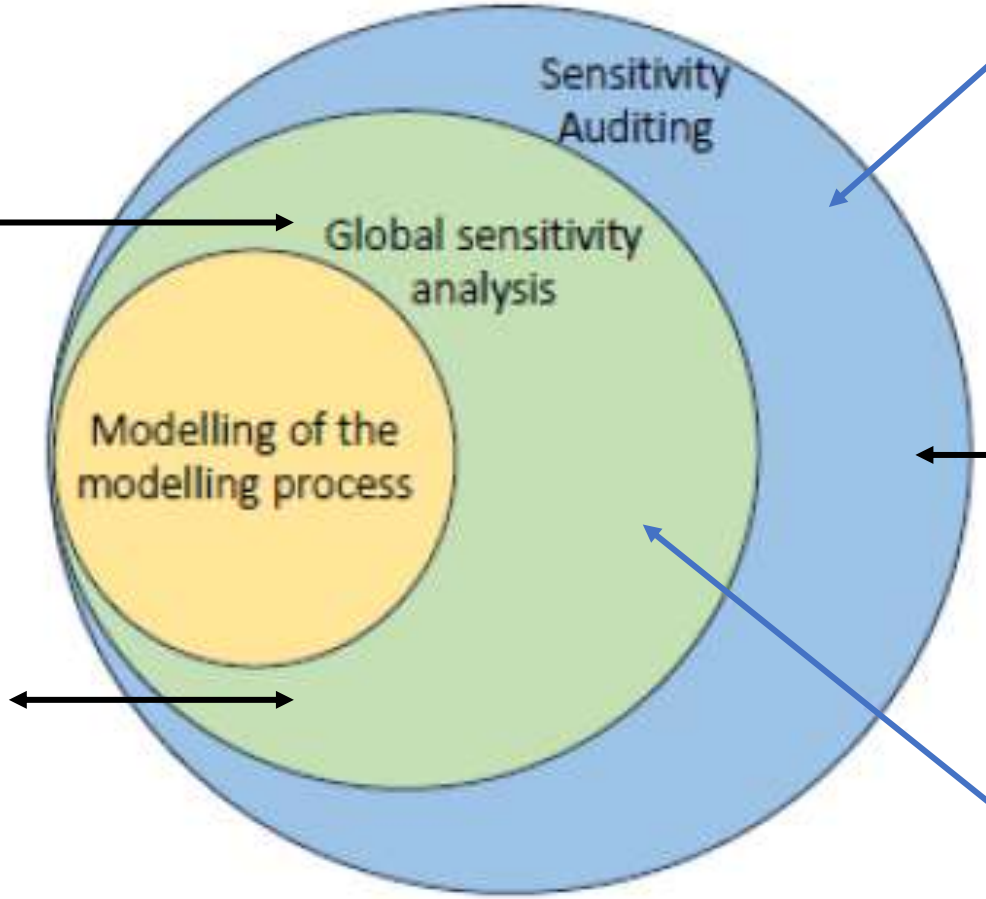
A short analysis of norms and counter-norms in modelling, discussing how models may misuse their epistemic authority for reasons of occasion, opportunity and interest.

Outline:
Narratives and counter-narratives,
State of exception,
Seeking Cinderella,
Reformation

Ranking the Rankers

Ranking the Rankers? We investigate using global sensitivity analysis the properties of the science-wide author databases' standardised citation indicators produced since 2015 by a



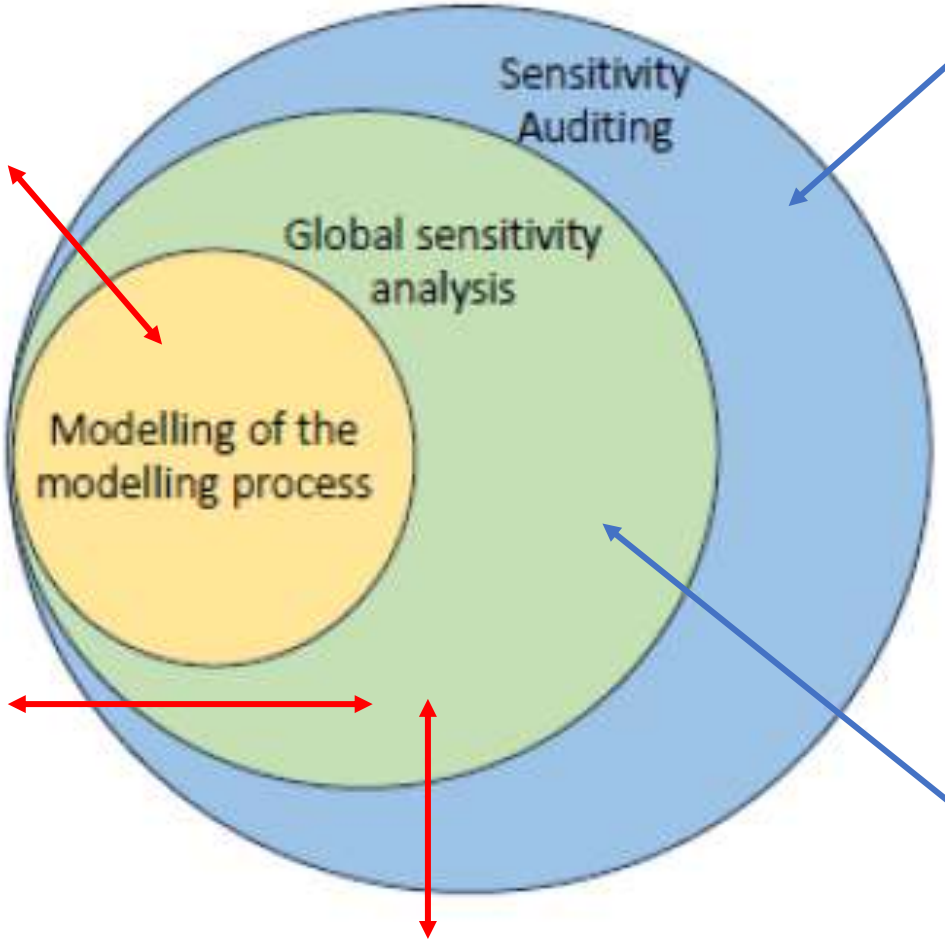


Normative quality

Technical Quality

Normative quality

Multiverse analysis



Perturbed
Physics Ensemble

Technical Quality

Exploratory
modelling analysis (EMA)

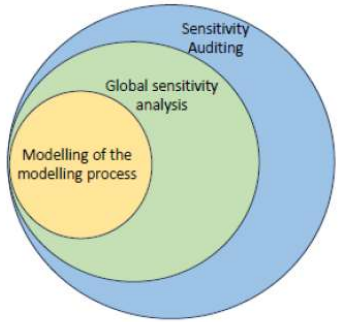
Futures
Volume 144, December 2022, 103041

Unpacking the modelling process via sensitivity auditing

Samuele Lo Piano [a], Razi Sheikholeslami [b], Arnald Puy [c d e], Andrea Saltelli [f]

Show more

2022



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Home > Statistical Methods & Applications > Article

Robustification of structural equation modelling via global sensitivity analysis

Original Paper | Published: 11 March 2025
(2025) Cite this article

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Alessio Lachi, Josep Llach, Jordi Perramon, Michela Baccini & Andrea Saltelli

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2025

Environmental Science & Policy
Volume 142, April 2023, Pages 99-111

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]

2023

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

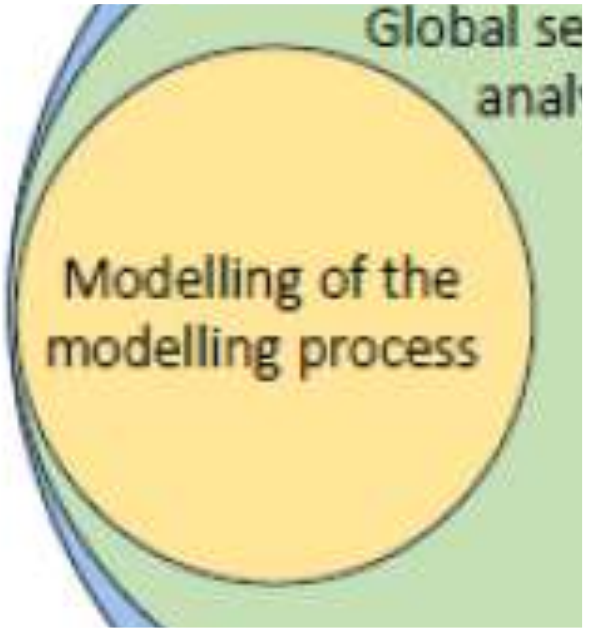
First published: 14 November 2023 | https://doi.org/10.1111/risa.14248

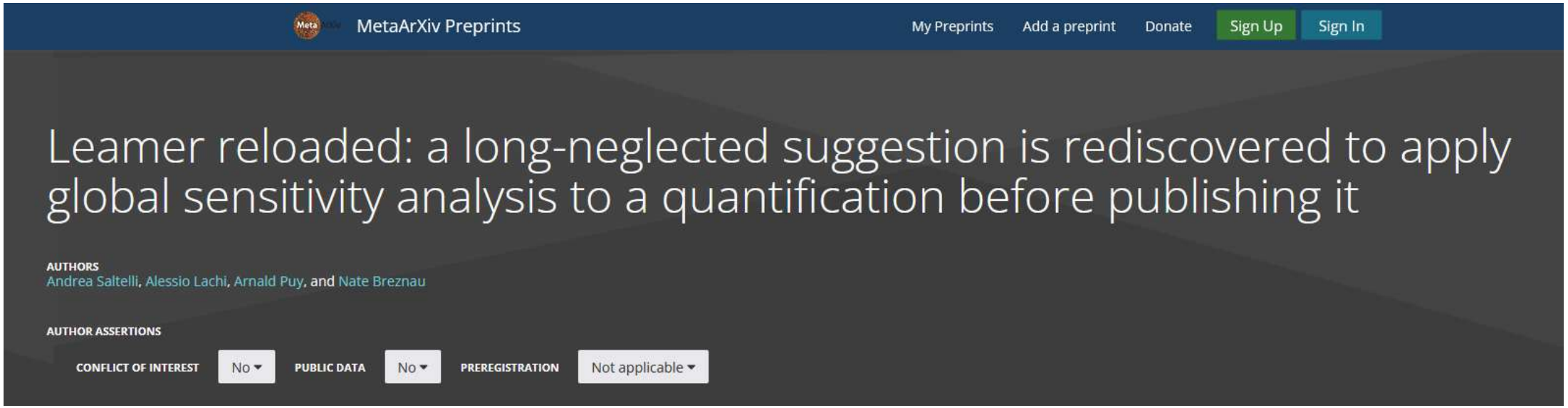
Figures Refer

2023

The multiverse

The universe of uncertainty that didn't hide: reaching out to multiverse analysis

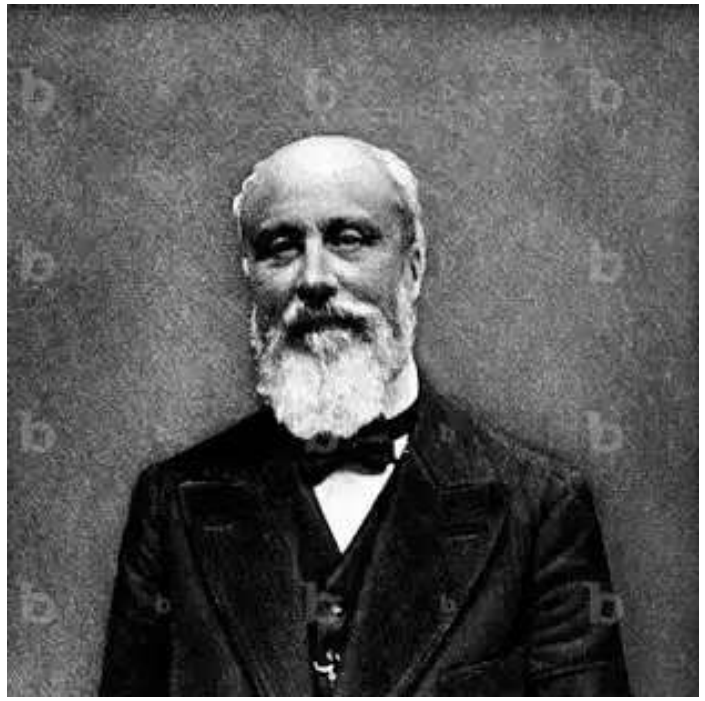




Models are fragile

"… inferences from mathematical models of phenomena to real physical applications must also be demonstrated to be approximately correct when the assumptions of the model are only approximately true" [1]

Pierre Duhem (1861–1916) and his 'Principle of stability'



[1] S. C. Fletcher, 'The Principle of Stability', Philosopher's Imprint, vol. 20, no. 3, 2020, Accessed: Sep. 08, 2024. [Online].

Models are fragile

Duhem's principle of stability [1], and the occurrence of either Butterfly [2] or Hawkmoth effects [3].

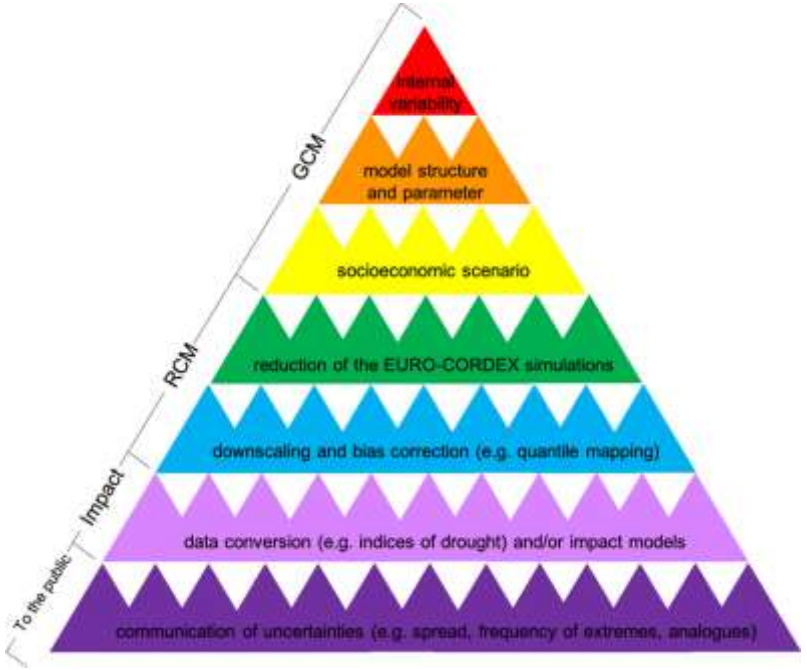
The accumulation of parametric error in a model, the so-called uncertainty cascade [4], that is the subject of global sensitivity analysis studies.

[1] S. C. Fletcher, 'The Principle of Stability', Philosopher's Imprint, vol. 20, no. 3, 2020, Accessed: Sep. 08, 2024. [Online].

[2] H. G. Schuster, Deterministic Chaos: An Introduction, 2nd Rev edition. Weinheim: Vch Pub, 1998.

[3] E. Winsberg, 'Appendix: Structural Stability and the "Hawkmoth Effect"', in Philosophy and Climate Science, Cambridge: Cambridge University Press, 2018, pp. 232–246. doi: 10.1017/9781108164290.016.

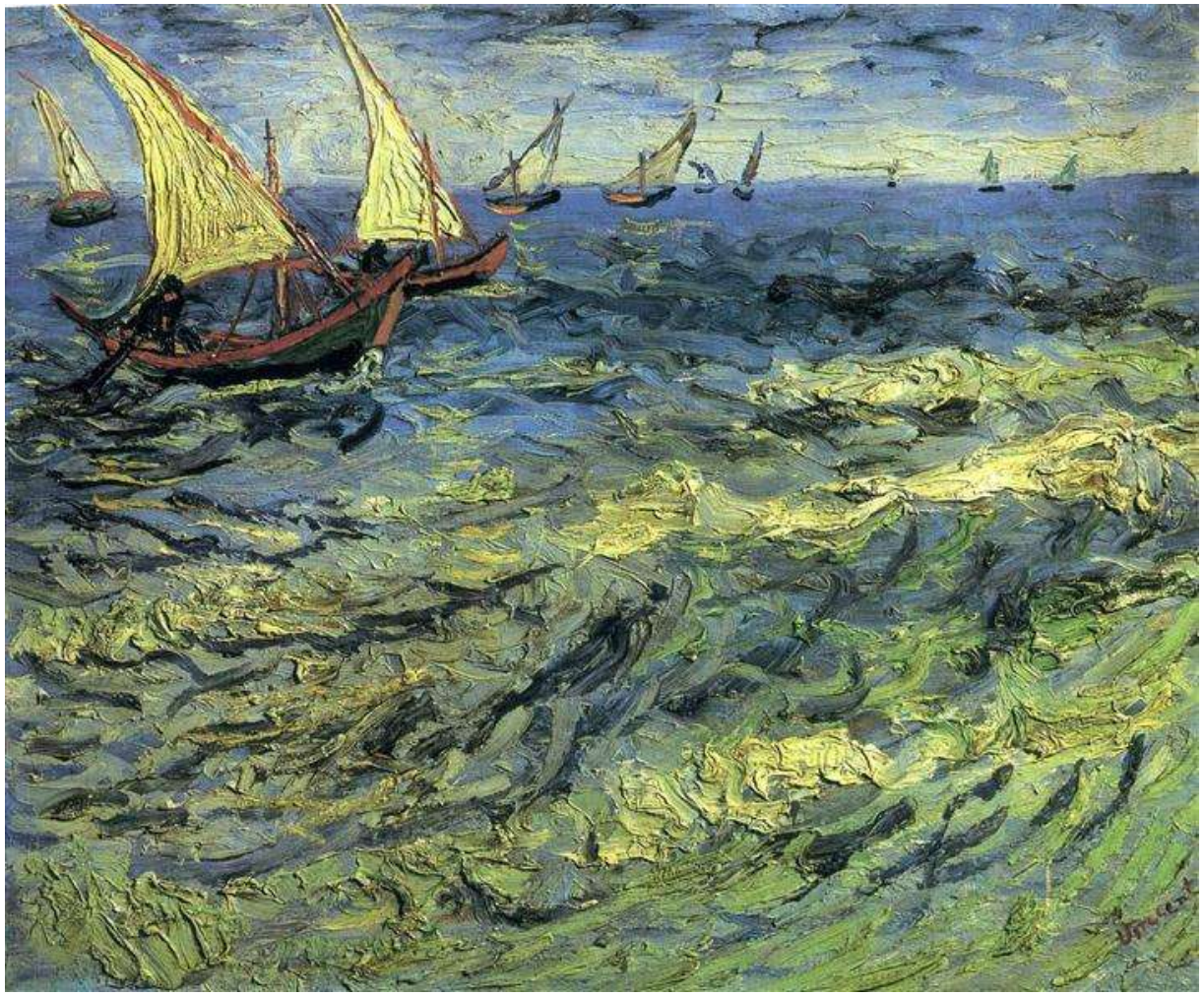
[4] M. Christie, A. Cliffe, P. Dawid, and S. S. Senn, Simplicity, Complexity and Modelling. Wiley, 2011.



"I have proposed a form of organised sensitivity analysis that I call 'global sensitivity analysis' in which a neighborhood of alternative assumptions is selected and the corresponding interval of inferences is identified.
Conclusions are judged to be sturdy only if the neighborhood of assumptions is wide enough to be credible and the corresponding interval of inferences is narrow enough to be useful."

Edward E. Leamer, 1990, Let's Take the Con Out of Econometrics, *American Economics Review*, 73 (March 1983), 31-43.

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‡

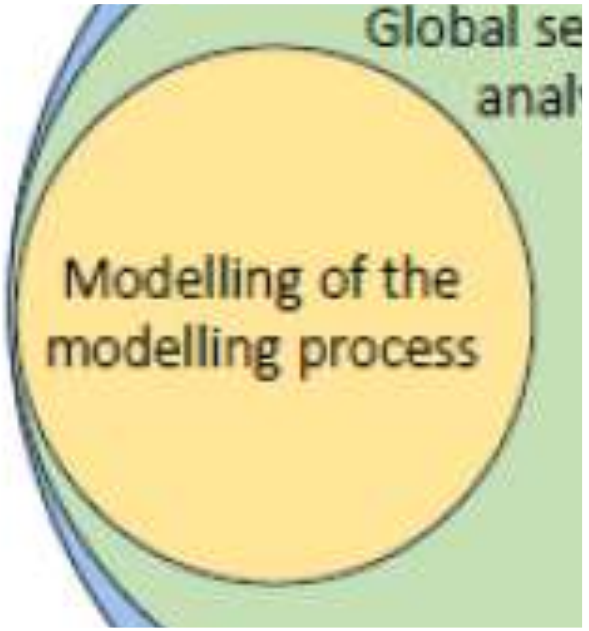
14 Nov 2013

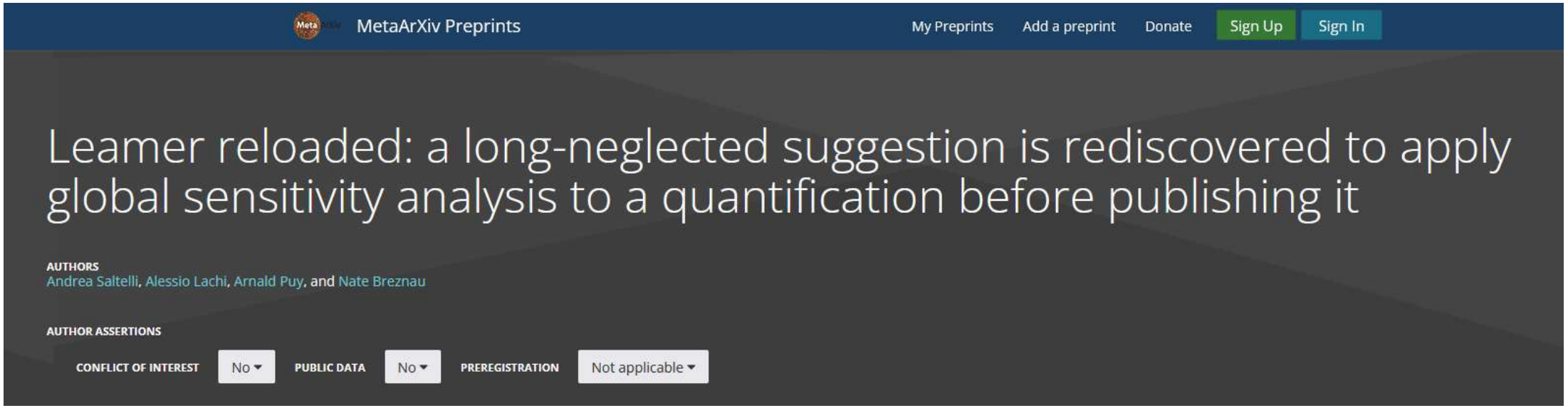
Can global SA help?

PNAS RESEARCH ARTICLE | SOCIAL SCIENCES OPEN

Observing many researchers using the same data and hypothesis reveals a hidden universe of uncertainty

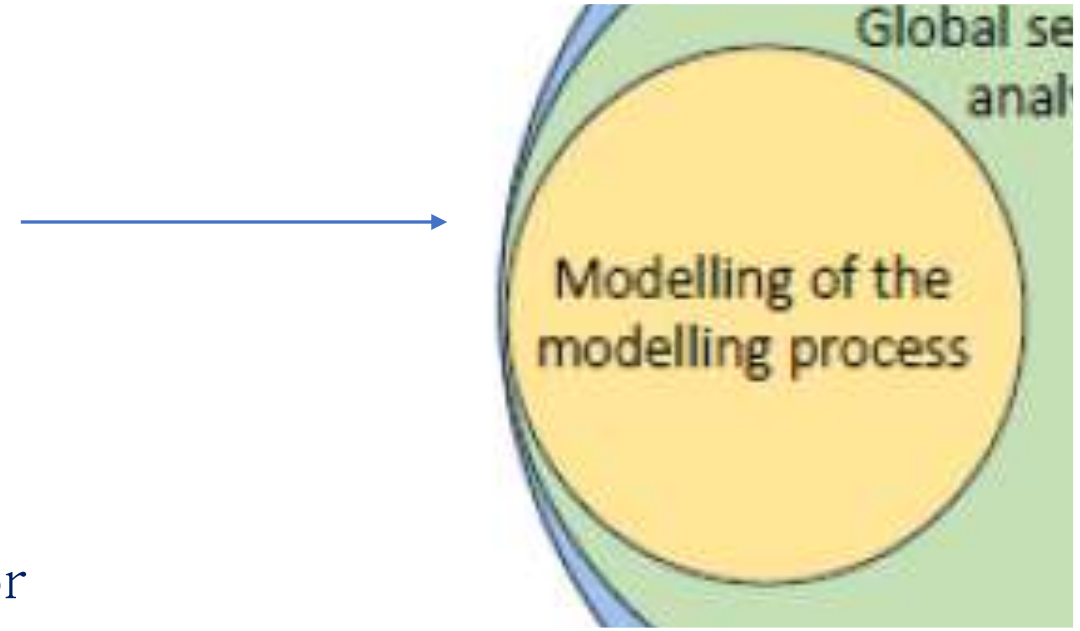
The universe of uncertainty that didn't hide: reaching out to multiverse analysis





A modelling of the modelling process of existing demographic projections, because:

- ➔ They are all important / growth and demography go hand in hand
- ➔ Existing projections (e.g. The 2024 UN World Population Prospects) leave room for doubt
- ➔ Some important assumptions (e.g. rebound effect, world replacement rate) are uncertain or controversial
- ➔ What a model can and cannot say



What Is Demographic Projection?

https://www.alamy.com/vector-illustration-of-social-and-demographic-world-map-on-blue-background-image365832606.html?

Definition

- A **demographic projection** estimates the future population size and structure (by age, sex, location) using current data and assumptions about fertility, mortality, and migration.
- It is not a prediction but a **scenario-based simulation** of plausible futures.

What Is Demographic Projection?

https://www.alamy.com/vector-illustration-of-social-and-demographic-world-map-on-blue-background-image365832606.html?

Why It Matters

- Critical for planning: labor markets, healthcare, pensions, education, urbanization.
- Shapes national policy, global development goals, and climate pathway modeling (e.g., SSPs).

China’s Trajectory

From Boom to Bust

- Total Fertility Rate dropped from ~6 in 1960s to **~1.0 in 2023**—far below replacement.
- China’s population **peaked in 2022**, now declining faster than expected

- **"1-2-4 Society"**
- One child supports **two parents** and **four grandparents**.
- Unsustainable dependency ratio with severe implications for pensions, care, and consumption

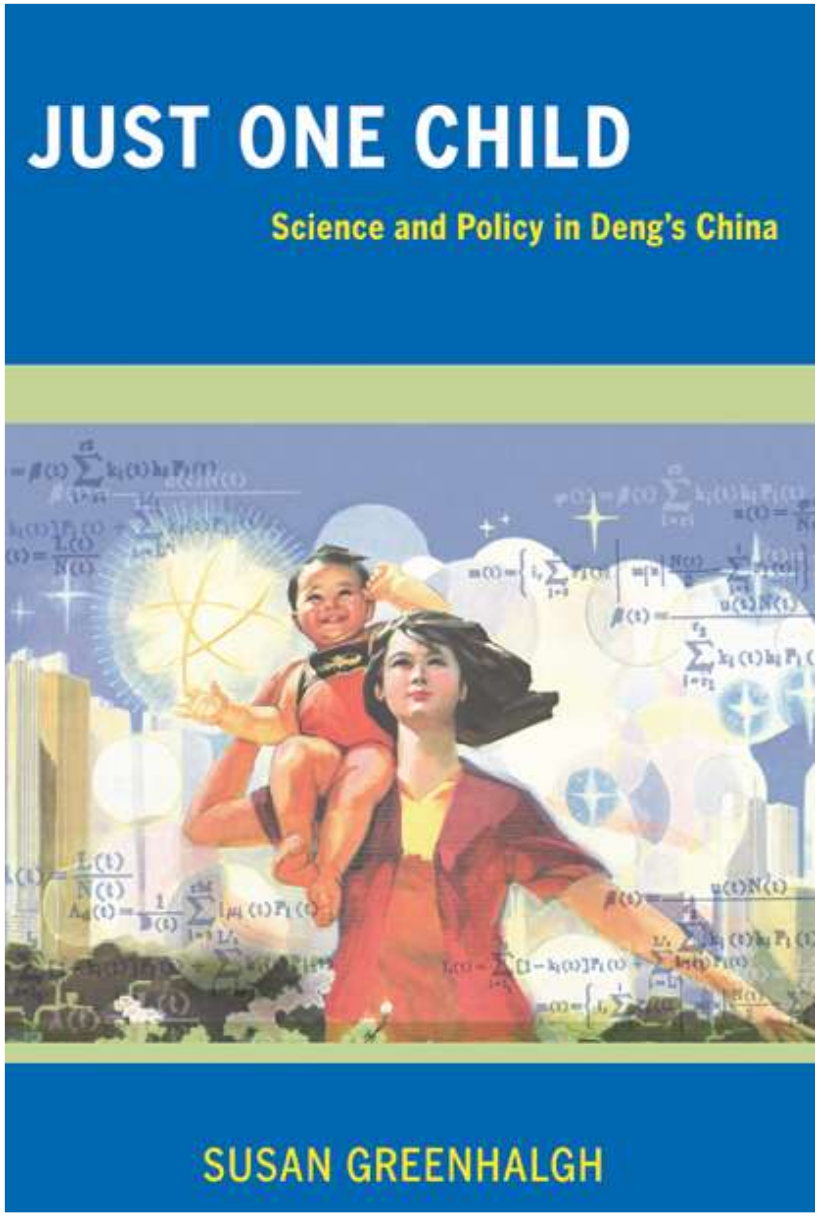
- **Legacy of One-Child Policy**

https://rebekahpothaar.medium.com/

Data Challenges in Chinese Demography

- **Statistical Unreliability**
- Historic data manipulated to meet political goals (e.g., birth quotas).
- Population size in censuses **adjusted retroactively**.
- Current estimates may undercount births or exaggerate migration.

- **Epistemic Consequences**
- Faulty data fed into **policy-justifying models**, creating a feedback loop of mistaken certainty.
- Long-term projections (e.g., 4+ billion in 2080) based on flawed assumptions now widely discredited



Mathematical Modelling, Vol. 2, pp. 109–121, 1981
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0270-0255/81/020109-13$02.00/0
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ON STABILITY THEORY OF POPULATION SYSTEMS AND CRITICAL FERTILITY RATES

SONG JIAN AND YU CHING-YUAN

Beijing Institute of Information Processing and Control
P.O. Box 3905
Beijing, People's Republic of China

Communicated by Ervin Y. Rodin

(*Received November 7, 1980*)

Copyright © IFAC Control Science and Technology for Development, Beijing, 1985

SYSTEMS SCIENCE AND CHINA'S ECONOMIC REFORMS

Jian Song

Institute of Information and Control, Beijing, China

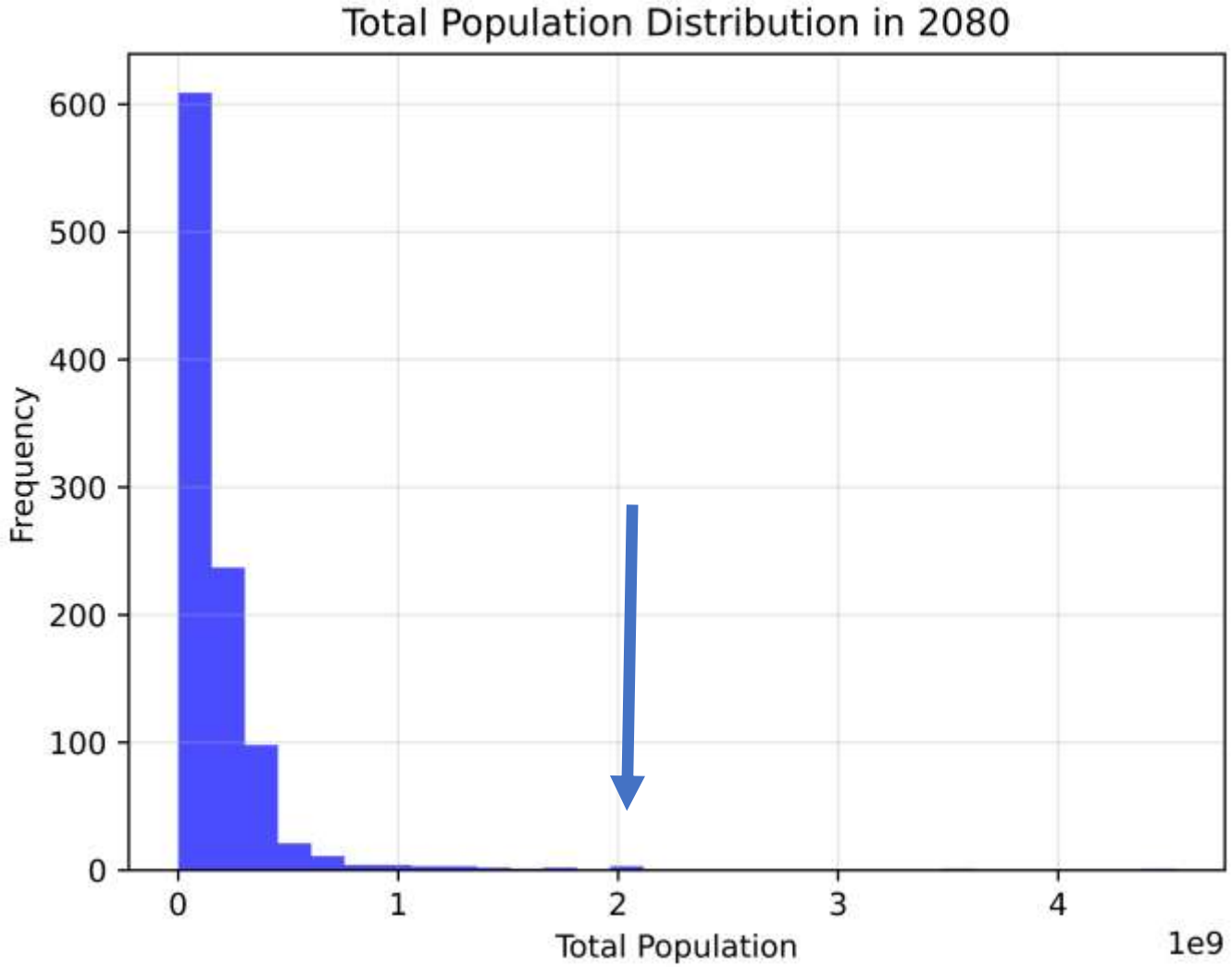
Sources for the model used

Around 40 parameters were randomized: 32 demographic figures plus 5 model hyperparameters. The demographic ones include:

- Survival rates for each age group (15 in total),
- Baseline fertility rates for the fertile female age groups (5),
- Initial population composition (14 groups — the 15th is implied since they must sum to 1),
- Infant survival rate (1),
- Proportion of females in the population (1).

The numerical indices (0–14) denote which age groups these refer to — 14 being the elderly group

There's a fat upper tail reaching up to two billions, but a large portion of the 1,000 simulations actually undershoot the 700 million population target
(work in progress)



Sensitivity analysis

Powering up

2024

ELSEVIER

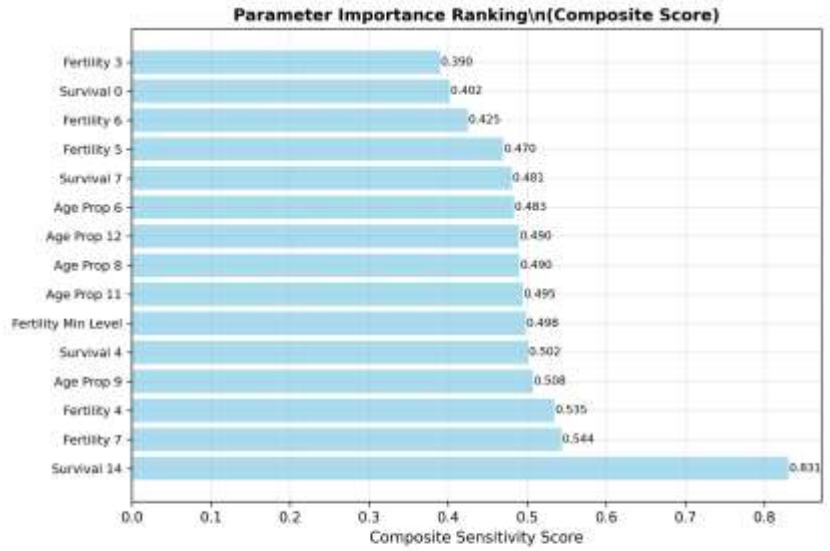
Environmental Modelling & Software

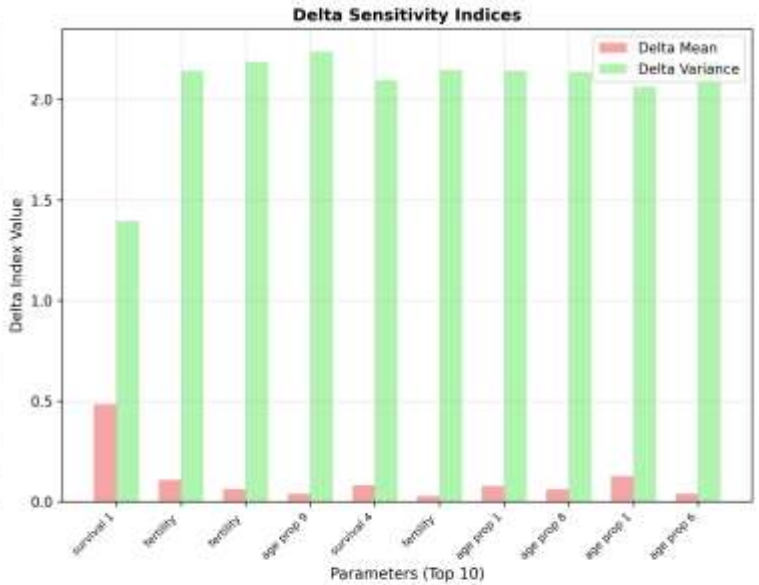
Volume 174, March 2024, 105977

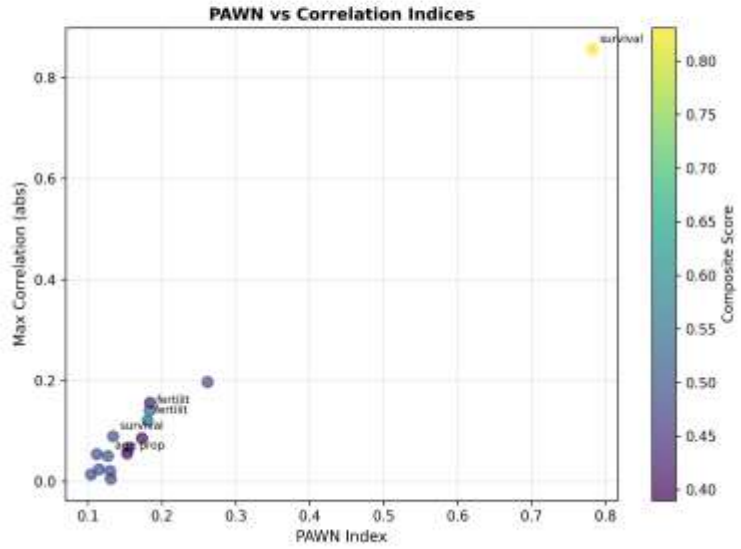
An annotated timeline of sensitivity analysis

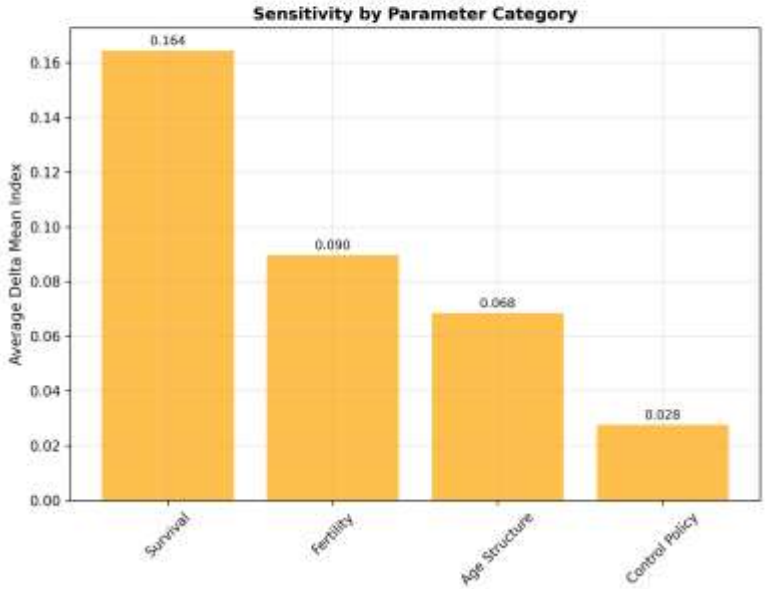
Stefano Tarantola [a], Federico Ferretti [a], Samuele Lo Piano [b], Mariia Kozlova [c], Alessio Lachi [d], Rossana Rosati [a], Arnald Puy [e], Pamphile Roy [f], Giulia Vannucci [g], Marta Kuc-Czarnecka [h], Andrea Saltelli [i j]

Sensitivity analysis: survival elderly group most important



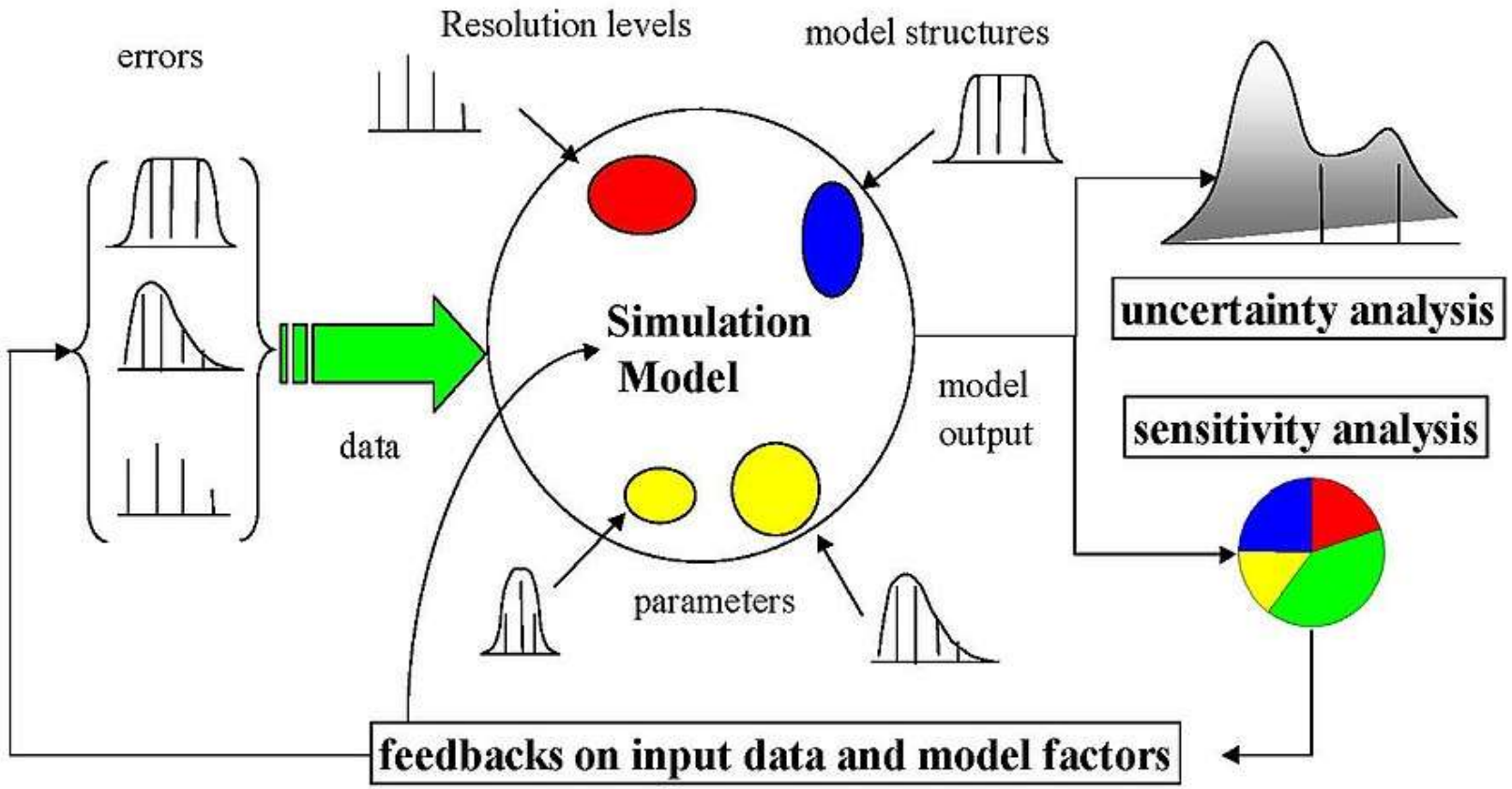






The delta sensitivity index refers to the Borgonovo moment-independent sensitivity index. The other measures are PAWN and variance based total sensitivity indices (work in progress)

The End



1999 figure from Stefano Tarantola: already a multiverse?

Methods Used in Demographic Projections

Deterministic Models

- **Cohort-component method**: Tracks cohorts through time using age-specific fertility, mortality, and migration rates. Most widely used.

Probabilistic Models

- Incorporate **uncertainty and variability** in key parameters.
- Examples: Bayesian hierarchical models (used by UN), ensemble approaches.

Computational Advances

- **Microsimulation** for individual-level projection.
- **Multiverse analysis** or **analytic flexibility**: exploring multiple methodological "paths" to see how choices influence results.

Demographic Projection Models

Classical Models

- **Leslie matrix models** for age-structured population dynamics.
- **Lotka's renewal equations** for long-term growth.

Policy-Centric Models

- **Optimal control theory**: e.g., Olsder & Strijbos (1976) modeled birth rate as a control variable under economic constraints

Scenario-Based Frameworks

- **Shared Socioeconomic Pathways (SSPs)**: used in climate modeling; population is one of five key drivers.
- Differences between UN, IHME, and IIASA projections highlight **epistemic uncertainty**