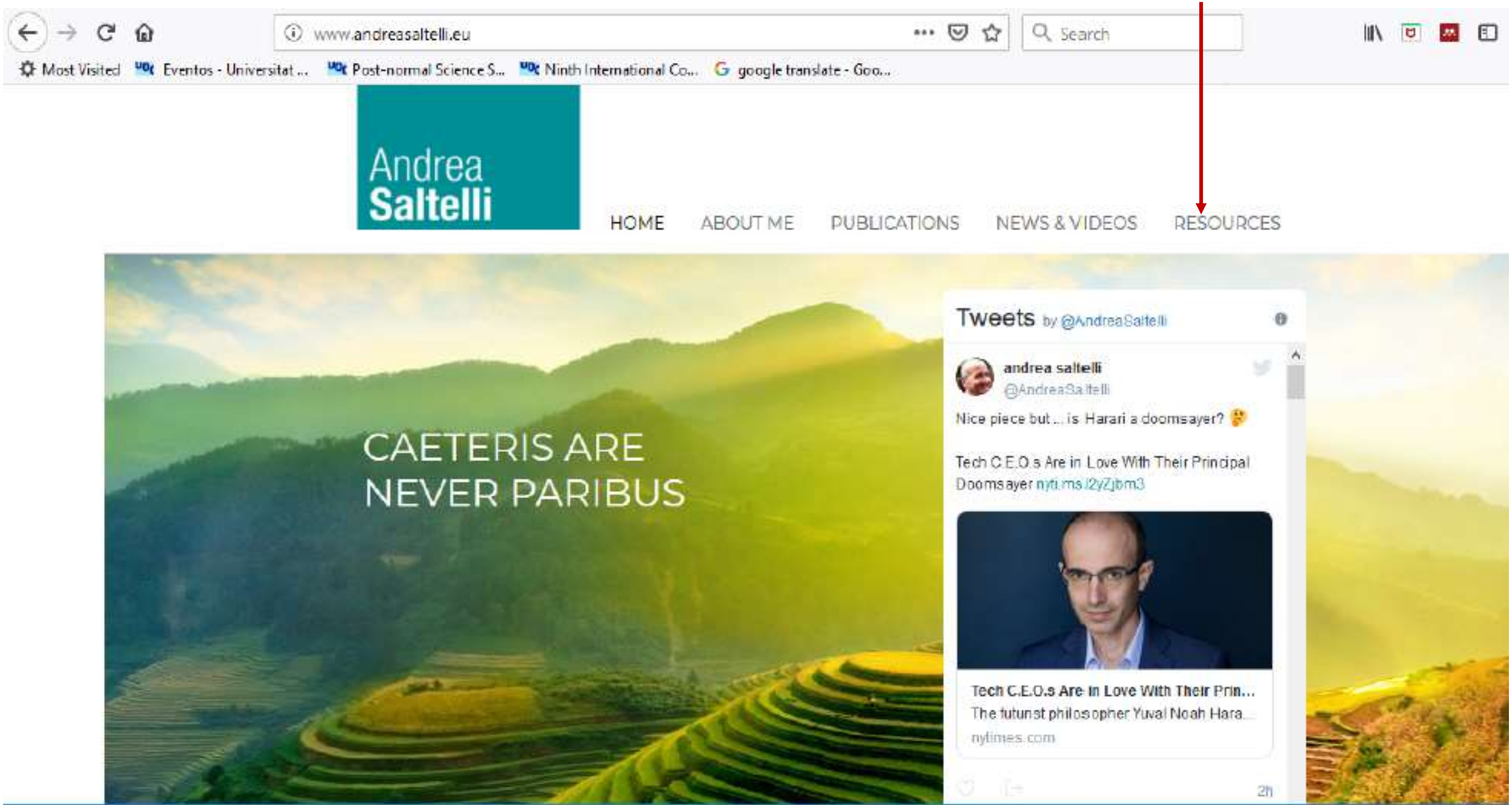
La scienza nel mirino: prove, controversie e partecipazione

Istituto Mario Negri Milano, Via Mario Negri, 2, 20156 Milano, aula B piano terra. 26 Giugno h 14.00 – 15.30

Andrea Saltelli
Centre for the Study of the Sciences and the Humanities (SVT), University of Bergen (UIB), and Open Evidence Research, Open University of Catalonia

Where to find material: www.andreasaltelli.eu



The topic of this first part

From the misuse of statistics to a problem in reproducibility in science; from this to an overall crisis of expertise, scientific evidence, practice and ethos.

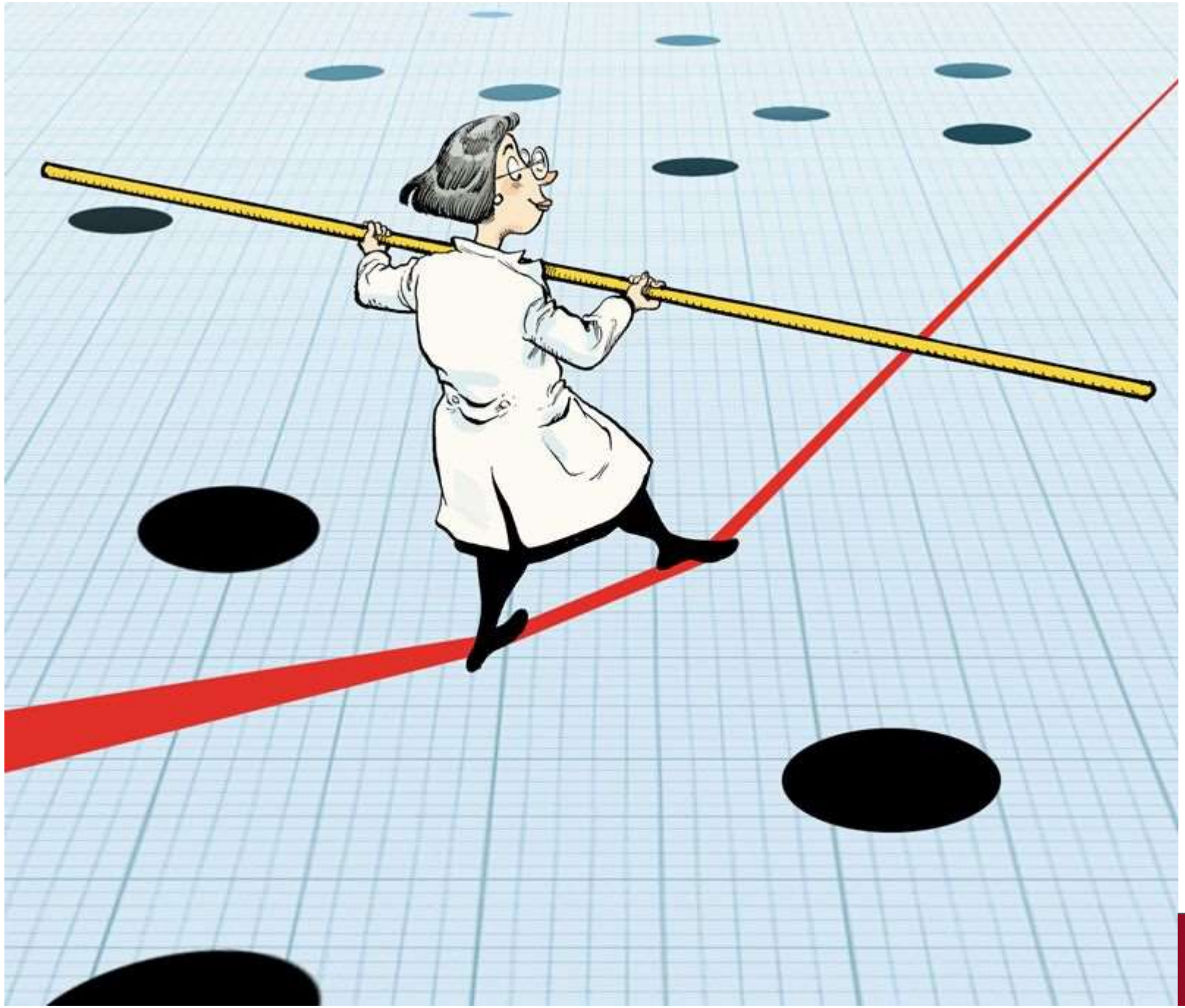
What about evidence based policy?

Numbers and trust

Frames

Crisis in statistics?

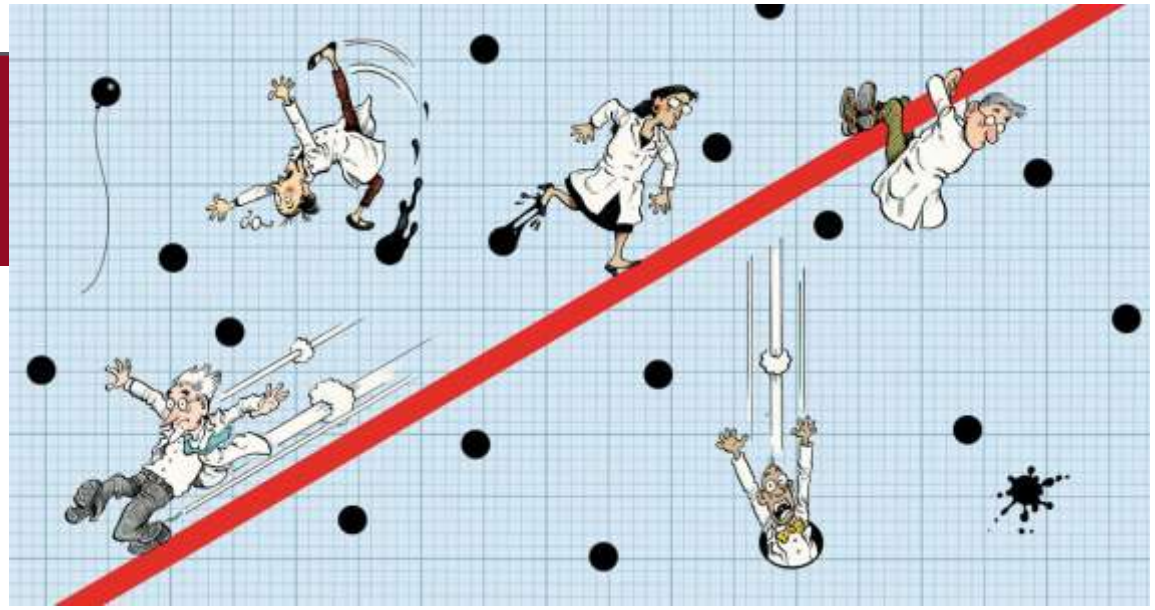
Statistics is experiencing a quality control crisis



Effect or no effect?

nature
International journal of science

nature
International journal of science

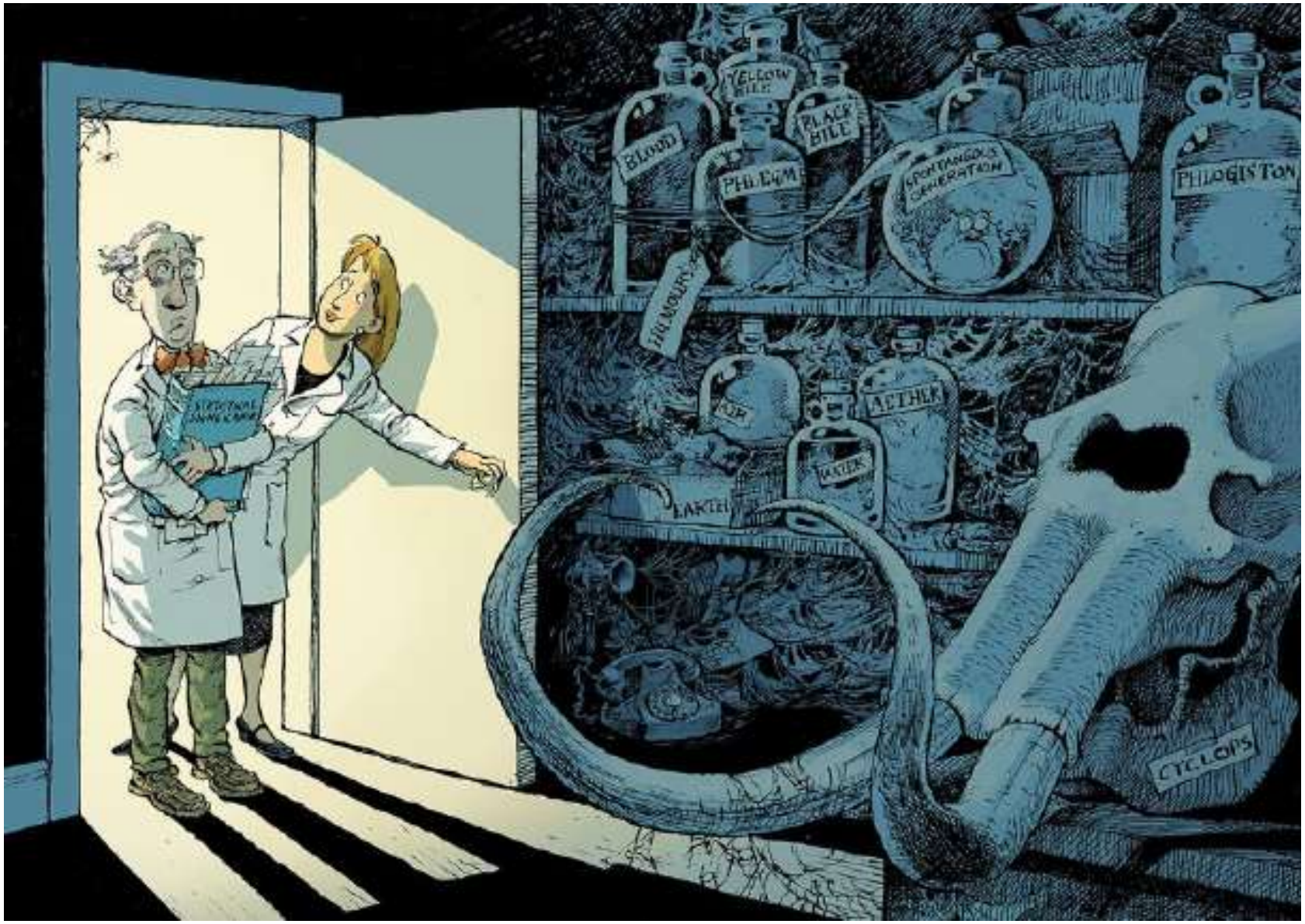


COMMENT · 28 NOVEMBER 2017

Five ways to fix statistics

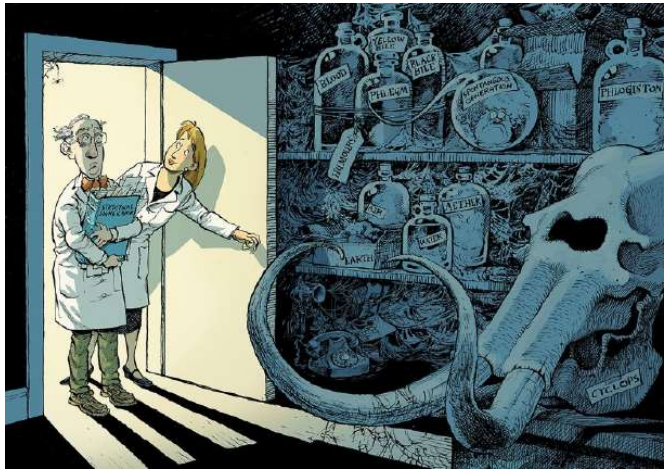
As debate rumbles on about how and how much poor statistics is to blame for poor reproducibility, Nature asked influential statisticians to recommend one change to improve science. The common theme? The problem is not our maths, but ourselves.

Jeff Leek ✉, Blakeley B. McShane, Andrew Gelman ✉, David Colquhoun ✉, Michèle B. Nuijten ✉ & Steven N. Goodman ✉



Throw away the concept of statistical significance?

nature
International journal of science



COMMENT · 20 MARCH 2019

Scientists rise up against statistical significance

Valentin Amrhein, Sander Greenland, Blake McShane and more than 800 signatories call for an end to hyped claims and the dismissal of possibly crucial effects.

Valentin Amrhein ✉, Sander Greenland & Blake McShane

See the discussion on the blog of Andrew Gelman https://statmodeling.stat.columbia.edu/

P-hacking (fishing for favourable p-values) and **HARKing** (formulating the research **H**ypothesis **A**fter the **R**esults are **K**nown);
Desire to achieve a sought for – or simply publishable – result leads to fiddling with the data points, the modelling assumptions, or the research hypotheses themselves

Leamer, E. E. Tantalus on the Road to Asymptopia. J. Econ. Perspect. 24, 31–46 (2010).

Kerr, N. L. HARKing: Hypothesizing After the Results are Known. Personal. Soc. Psychol. Rev. 2, 196–217 (1998).

A. Gelman and E. Loken, "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," 2013.

IN PRACTICE

Cargo-cult statistics and scientific crisis

The mechanical, ritualistic application of statistics is contributing to a crisis in science. Education, software and peer review have encouraged poor practice – and it is time for statisticians to fight back. By **Philip B. Stark** and **Andrea Saltelli**

Crisis in science?

There have recently been alarms as to the scientific quality arrangement is several disciplines. The most visible symptom of this possible dysfunction is the so-called reproducibility crisis

On the radar: October 2013

The Economist

HOW SCIENCE GOEs WRONG.

Essay

Why Most Published Research Findings Are False

John P. A. Ioannidis

2005

John P. A. Ioannides

J. P. A. Ioannidis, Why Most Published Research Findings Are False, PLoS Medicine, August 2005, 2(8), 696-701.

Failed replications, entire subfields going bad, fraudulent peer reviews, predatory publishers, perverse metrics, statistics on trial …

… misleading science advice, institutions on denial, a new breed of science wars

The crisis is methodological, epistemological, ethical and metaphysical

Futures
Volume 91, August 2017, Pages 5-11

What is science's crisis really about?

Andrea Saltelli [a, b] ✉, Silvio Funtowicz [a]

Futures
Volume 104, December 2018, Pages 85-90

Why science's crisis should not become a political battling ground

Andrea, Saltelli ✉

…or a broader crisis?

Today, all that is controversial and relevant … operates simultaneously in science, technology, economics, law and policy…

COMMENT · 21 MAY 2019

Views from a continent in flux

Nature asked nine leading Europeans to pick their top priority for science at this pivotal point. Love, money, and trust got most votes.

Social media gives this cocktail unprecedented reach and acceleration

COMMENT · 21 MAY 2019

Views from a continent in flux

nature
International journal of science

Nature asked nine leading Europeans to pick their top priority for science at this pivotal point. Love, money, and trust got most votes.

The powerful agents of post-truth

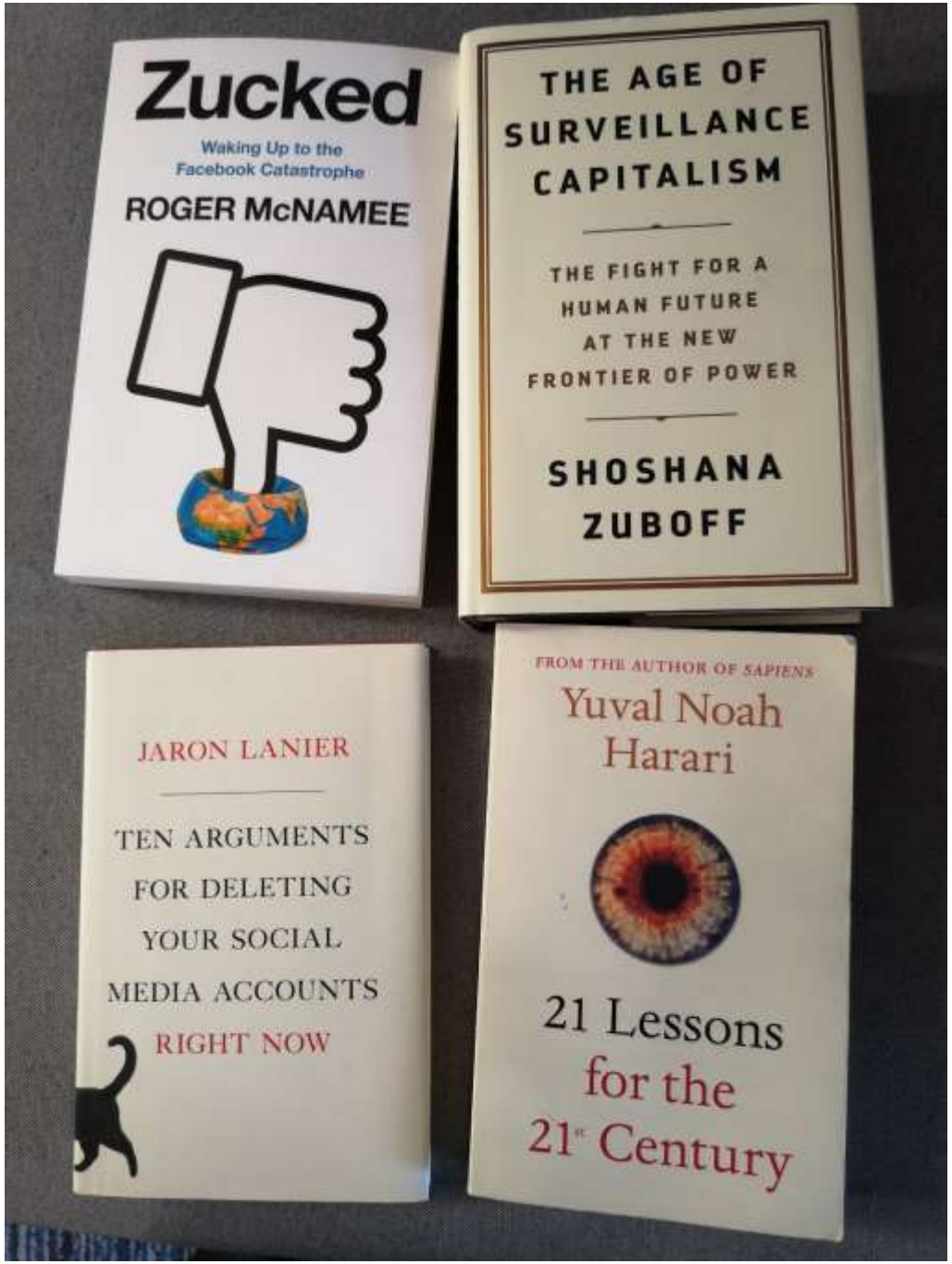
Jaron Lanier

Poisonous algorithms to stoke hatred and division

Yuval Noah Harari, Homo Deus 2015 & 21 Lessons for the 21st Century, 2018.

Jaron Lanier, 2018 Ten Arguments for Deleting Your Social Media Accounts Right Now

https://www.theguardian.com/society/2018/aug/23/russian-trolls-spread-vaccine-misinformation-on-twitter



How deep?

New or old?

Platform or surveillance?

Huxley or Orwell?

Expertise?

“People in this country have had enough of experts” (Michael Gove)

P. Stephens, Financial Times, June 23 2016, https://www.ft.com/content/bfb5f3d4-379d-11e6-a780-b48ed7b6126f

Andrea Saltelli, and Silvio Funtowicz, “Science cannot solve these problems alone because it helped to create them in the first place”, The Guardian, July 14, https://www.theguardian.com/science/political-science/2016/jul/14/six-leading-scientists-give-perspectives-on-uk-science-after-brexit?CMP=share_btn_tw

Present zeitgeist = end of expertise? Or an older problem?

Issues tend to become “wicked” “where goal-formulation, problem-definition and equity issues meet”

Horst W. J. Rittel

Policy Sciences 4 (1973), 155–169

Dilemmas in a General Theory of Planning*

HORST W. J. RITTEL
Professor of the Science of Design, University of California, Berkeley

MELVIN M. WEBBER
Professor of City Planning, University of California, Berkeley

How do we appraise the work of experts when this feeds into policy? A complex matter for Clark and Majone

W. C. Clark and G. Majone, "The Critical Appraisal of Scientific Inquiries with Policy Implications," Sci. Technol. Hum. Values, vol. 10, no. 3, pp. 6–19, Jul. 1985.

Table 1. Critical criteria.

Critical Role	Critical Mode: Input	Critical Mode: Output	Critical Mode: Process
Scientist	Resource and time constraints; available theory; institutional support; assumptions; quality of available data; state of the art.	Validation; sensitivity analyses; technical sophistication; degree of acceptance of conclusions; impact on policy debate; imitation; professional recognition.	Choice of methodology (e.g., estimation procedures); communication; implementation; promotion; degree of formalization of analytic activities within the organization.
Peer Group	Quality of data; model and/or theory used; adequacy of tools; problem formulation. Input variables well chosen? Measure of success specified in advance?	Purpose of the study. Are conclusions supported by evidence? Does model offend common sense? Robustness of conclusions; adequate coverage of issues.	Standards of scientific and professional practice; documentation; review of validation techniques; style; interdisciplinarity.
Program Manager or Sponsor	Cost; institutional support within user organization; quality of analytic team; type of financing (e.g., grant vs. contract).	Rate of use; type of use (general education, program evaluation, decisionmaking, etc.); contribution to methodology and state of the art; prestige. Can results be generalized, applied elsewhere?	Dissemination; collaboration with users. Has study been reviewed?
Policymaker	Quality of analysts; cost of study; technical tools used (hardware and software). Does problem formulation make sense?	Is output familiar and intelligible? Did study generate new ideas? Are policy indications conclusive? Are they consonant with accepted ethical standards?	Ease of use; documentation. Are analysts helping with implementation? Did they interact with agency personnel? With interest groups?
Public Interest Groups	Competence and intellectual integrity of analysts. Are value systems compatible? Problem formulation acceptable? Normative implications of technical choices (e.g., choices of data).	Nature of conclusions; equity. Is analysis used as rationalization or to postpone decision? All viewpoints taken into consideration? Value issues.	Participation; communication of data and other information; adherence to strict rules of procedure.

Scientists

Public Interest Groups

Critical mode

	Input	Output	Process
Scientists	Resource and time constraints; available theory; institutional support; assumptions; quality of available data; state of the art.	Validation; sensitivity analyses; technical sophistication; degree of acceptance of conclusions; impact on policy debate; imitation; professional recognition.	Choice of methodology (e.g., estimation procedures); communication; implementation; promotion; degree of formalization of analytic activities within the organization.
Public	Competence and intellectual integrity of analysts. Are value systems compatible? Problem formulation acceptable? Normative implications of technical choices (e.g., choices of data).	Nature of conclusions; equity. Is analysis used as rationalization or to postpone decision? All viewpoints taken into consideration? Value issues.	Participation; communication of data and other information; adherence to strict rules of procedure.

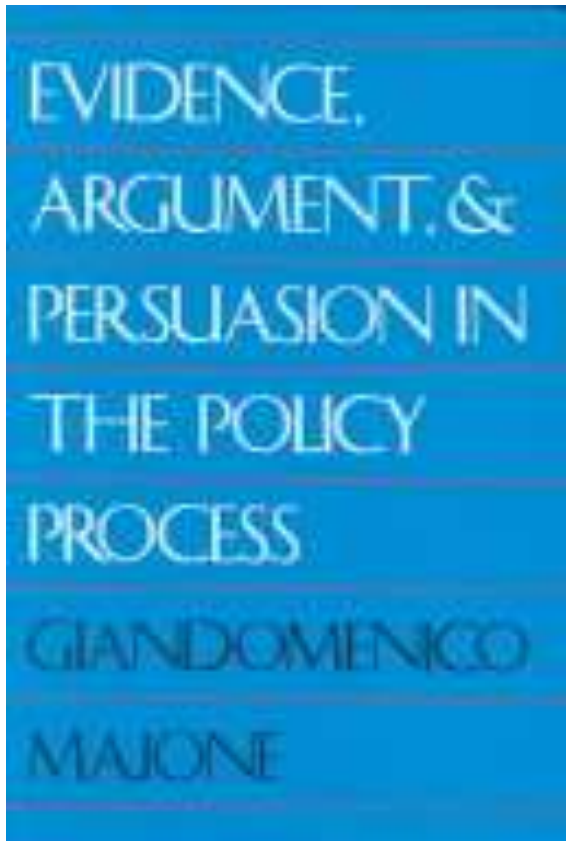
Evidence based policy

‘Policy based evidence’ has entered the public discourse

Warring parties accuse one another of the sin

“Greenpeace […] wants is policy based evidence making not evidence based policy making” (Sanderson, 2015) …

Wilkes, G., 2015, Free Lunch: Policy-based evidence-making, Financial Times, July 3.
Sanderson, A.B., 3 Feb 2015, Breitbart, see http://www.breitbart.com/london/2015/02/03/academic-attacks-greenpeace-for-ignoring-the-evidence-on-gm-crops/; the politician is UKIP Energy Spokesman Roger Helmer MEP.



"When science, technology, and public policy intersect, different attitudes, perspectives, and rules of argument come into sharp conflict. Scientific criteria of truth clash with legal standards of evidence and with political notions of what constitutes sufficient ground for action"

Futures
Volume 91, August 2017, Pages 62-71

Original research article

What is wrong with evidence based policy, and how can it be improved?

Andrea Saltelli [a, b, c], Mario Giampietro [a, c, d]

Power asymmetries in the framing of issues: those who have the deepest pockets marshal the best evidence ➔ Instrumental use of quantification to obfuscate

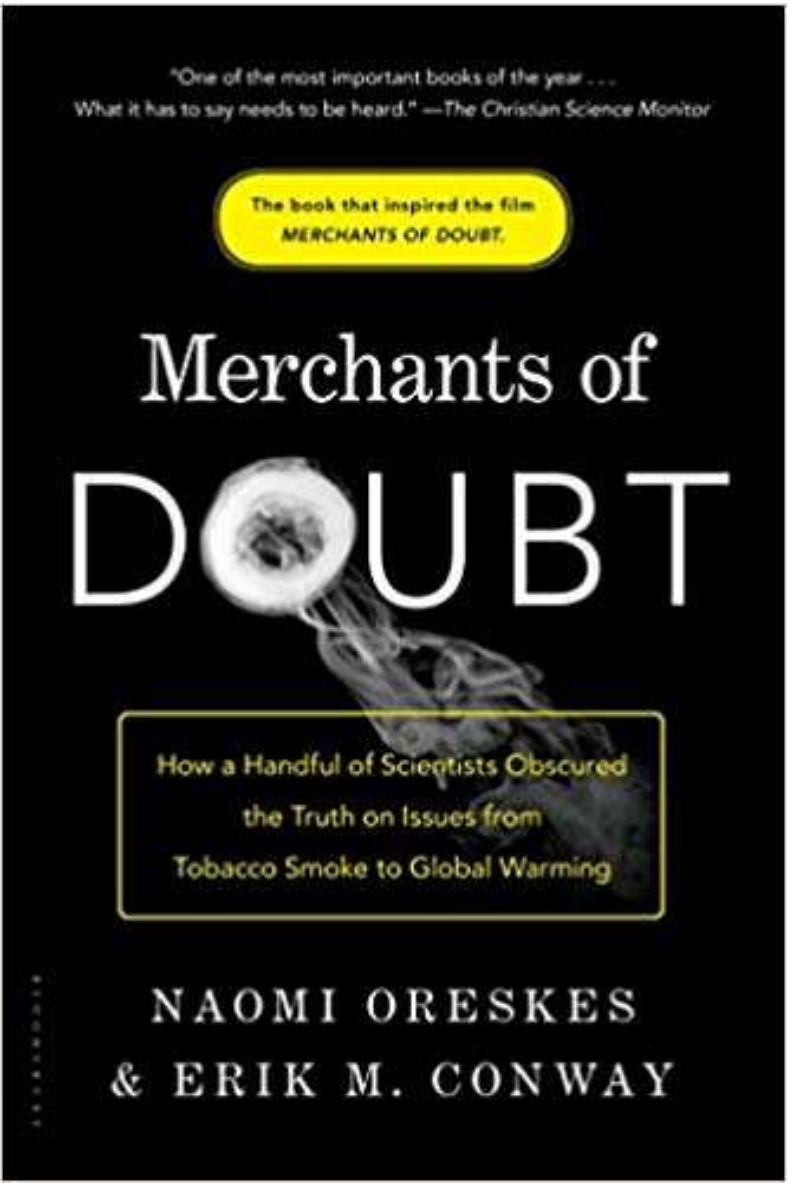
A. Saltelli and M. Giampietro, “What is wrong with evidence based policy, and how can it be improved?,” Futures, vol. 91, pp. 62–71, Feb. 2017.

September 12, 2016

See also https://www.theguardian.com/society/2016/apr/07/the-sugar-conspiracy-robert-lustig-john-yudkin, and the story of US President Dwight Eisenhower heart attack,…

“our findings suggest the industry sponsored a research program in the 1960s and 1970s that successfully cast doubt about the hazards of sucrose while promoting fat as the dietary culprit in CHD [coronary hearth disease]”

http://archinte.jamanetwork.com/article.aspx?articleid=2548255



Naomi Oreskes

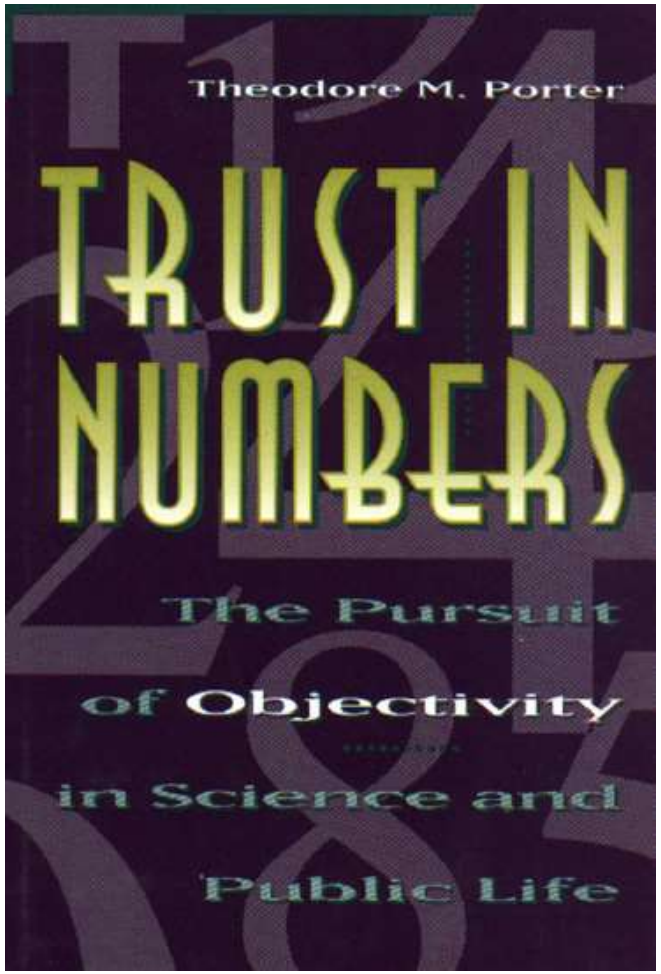
nature
International journal of science

Beware: transparency rule is a Trojan Horse

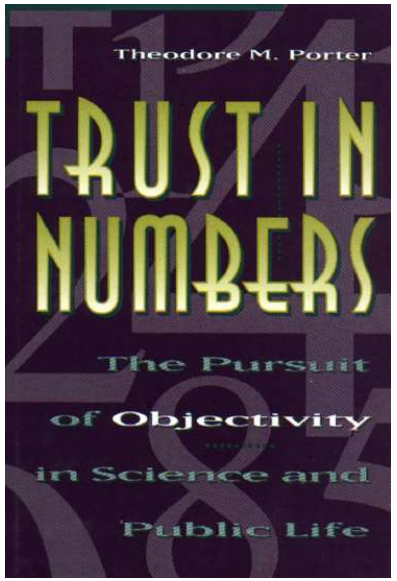
Like tobacco lobbyists and climate-change deniers, the US Environmental Protection Agency is co-opting scientific trappings to sow doubt, warns Naomi Oreskes.

Numbers and trust

Theodor
M. Porter



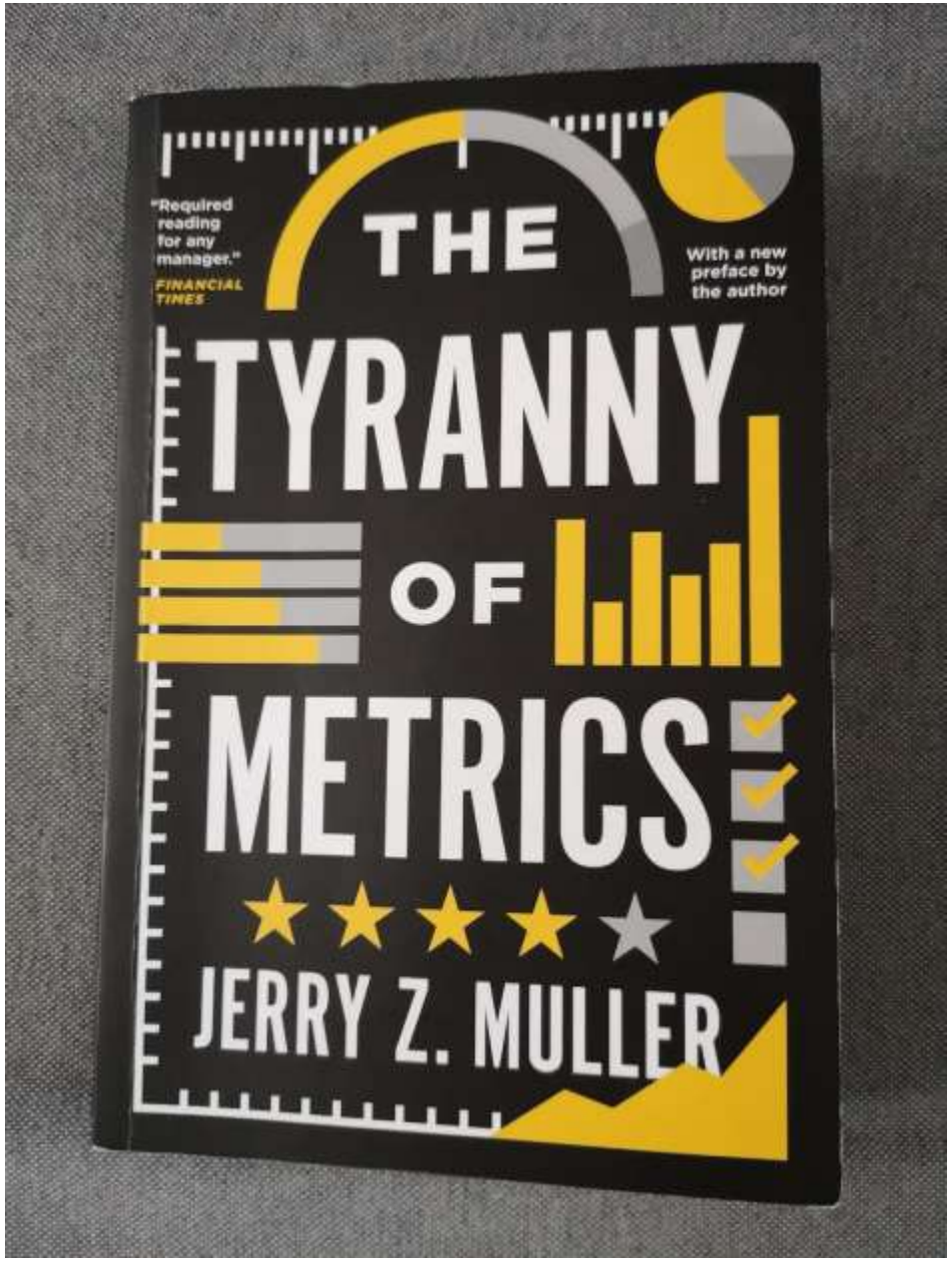
Theodore M. Porter, Trust in Numbers,
The Pursuit of Objectivity in Science and Public Life, Princeton 1995



p. 8: “Scientific objectivity thus provides an answer to a moral demand for impartiality and fairness.

Quantification is a way of making decisions without seeming to decide.

Objectivity lends authority to officials who have very little of their own.”



More reading

Frames

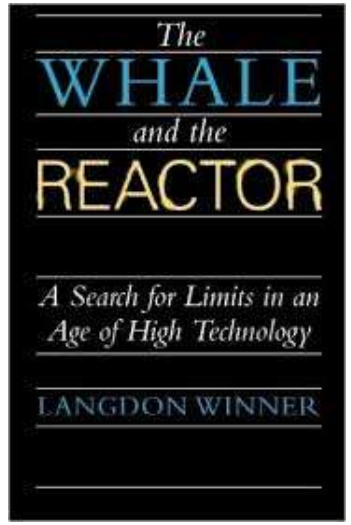
Frames

Most analyses offered as input to policy are framed as cost benefit analysis or risk analyses.

Langdon Winner

8

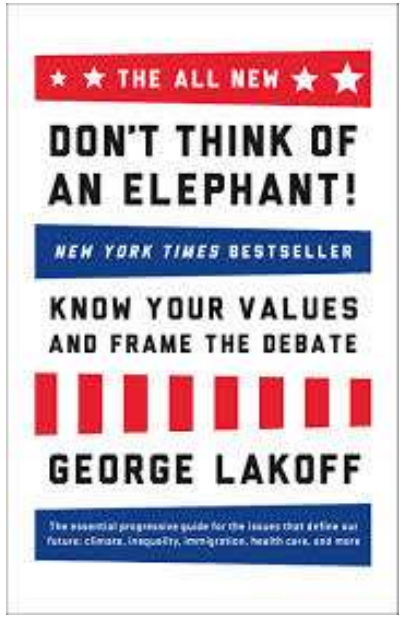
ON NOT HITTING THE TAR-BABY



Winner, L., 1986. The Whale and the Reactor: a Search for Limits in an Age of High Technology. The University of Chicago Press, 1989 edition.

Frames: The expression ‘tax relief’ is apparently innocuous but it suggests that tax is a burden, as opposed to what pays for road, hospitals, education and other infrastructures of modern life (Lakoff, 2004).

George Lakoff



Lakoff, G., 2010, Why it Matters How We Frame the Environment, Environmental Communication: A Journal of Nature and Culture, 4:1, 70-81.

Lakoff, G., 2004-2014, Don’t think of an elephant: know your values and frame the debate, Chelsea Green Publishing.

Second part: methods

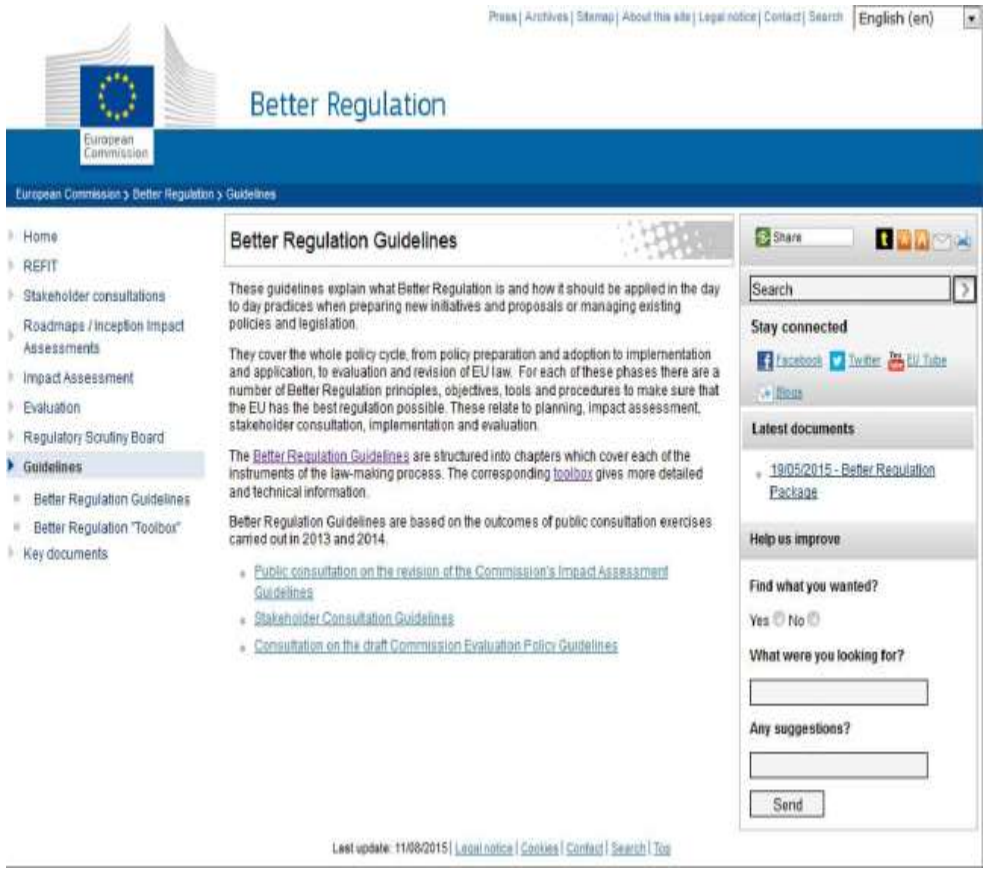
Sensitivity auditing
NUSAP
PNS
Indicators
Examples or practicum

Methods for responsible quantification

See slides of a recent course: 'Numbers for Policy'
http://www.andreasaltelli.eu/presentations/#Course

Sensitivity auditing

EC impact assessment guidelines: what do they say about sensitivity auditing ?



http://ec.europa.eu/smart-regulation/guidelines/docs/br_toolbox_en.pdf

p. 392

… where there is a major disagreement among stakeholders about the nature of the problem, … then sensitivity auditing is more suitable but sensitivity analysis is still advisable as one of the steps of sensitivity auditing.

Andrea Saltelli, Ksenia Aleksankina, William Becker, Pamela Fennell, Federico Ferretti, Niels Holst, Sushan Li, Qiongli Wu, Why so many published sensitivity analyses are false: a systematic review of sensitivity analysis practices, Environmental Modelling and Software, Volume 114, April 2019, Pages 29-39.

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.
[...]
The ultimate aim is to communicate openly and honestly the extent to which particular models can be used to support policy decisions and what their limitations are.

p. 393

“In general sensitivity auditing stresses the idea of honestly communicating the extent to which model results can be trusted, taking into account as much as possible all forms of potential uncertainty, and to anticipate criticism by third parties.”

The rules of sensitivity auditing

Rule 1: Check against rhetorical use of mathematical modelling;

Rule 2: Adopt an “assumption hunting” attitude; focus on unearthing possibly implicit assumptions;

Rule 3: Check if uncertainty been instrumentally inflated or deflated.

The rules of sensitivity auditing

Rule 4: Find sensitive assumptions before these find you; do your SA before publishing;

Rule 5: Aim for transparency; Show all the data;

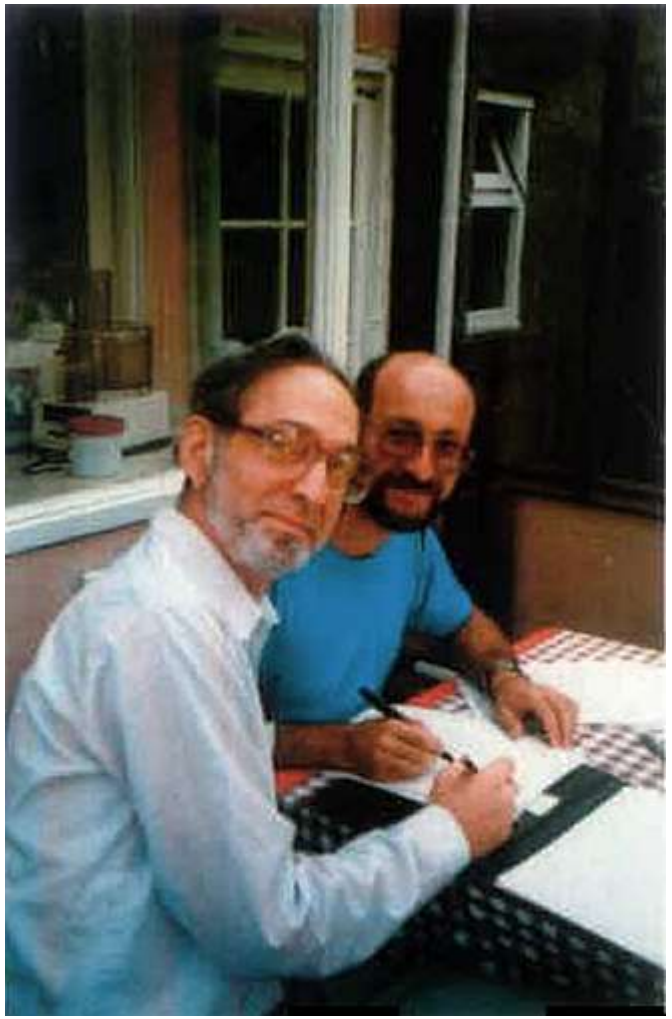
Rule 6: Do the right sums, not just the sums right; the analysis should not solve the wrong problem;

Rule 7: Perform a proper global sensitivity analysis.

NUSAP

NUSAP =

Numeral
Unit
Spread
Assessment
Pedigree



Jerome Ravetz and Silvio Funtowicz, circa 1988, at Sheffield

Numeral will usually be an ordinary number;

Unit refers to the units used in Numeral;

Spread is an assessment of the error in the value of the Numeral

Assessment is a summary of salient qualitative judgements about the information – this can be of statistical nature (a significance level) or more general, e.g. involving terms such as 'conservative' or 'optimistic'.

Pedigree is an evaluative description of the mode of production and of anticipated use of the information

Jeroen P. van der Sluijs, James S. Risbey and Jerry Ravetz, 2005, Uncertainty Assessment of VOC Emissions from Paint in the Netherlands Using the NUSAP System, Environmental Monitoring and Assessment (2005) 105: 229–259.

NUSAP pedigree matrix

Universiteit Utrecht

Example Pedigree matrix parameter strength

Code	Proxy	Empirical	Theoretical basis	Method	Validation
4	Exact measure	Large sample direct mmts	Well established theory	Best available practice	Compared with indep. mmts of same variable
3	Good fit or measure	Small sample direct mmts	Accepted theory partial in nature	Reliable method commonly accepted	Compared with indep. mmts of closely related variable
2	Well correlated	Modeled/derived data	Partial theory limited consensus on reliability	Acceptable method limited consensus on reliability	Compared with mmts not independent
1	Weak correlation	Educated guesses / rule of thumb est	Preliminary theory	Preliminary methods unknown reliability	Weak / indirect validation
0	Not clearly related	Crude speculation	Crude speculation	No discernible rigour	No validation

Jeroen van der Sluijs

http://www.nusap.net/

Example Pedigree matrix parameter strength

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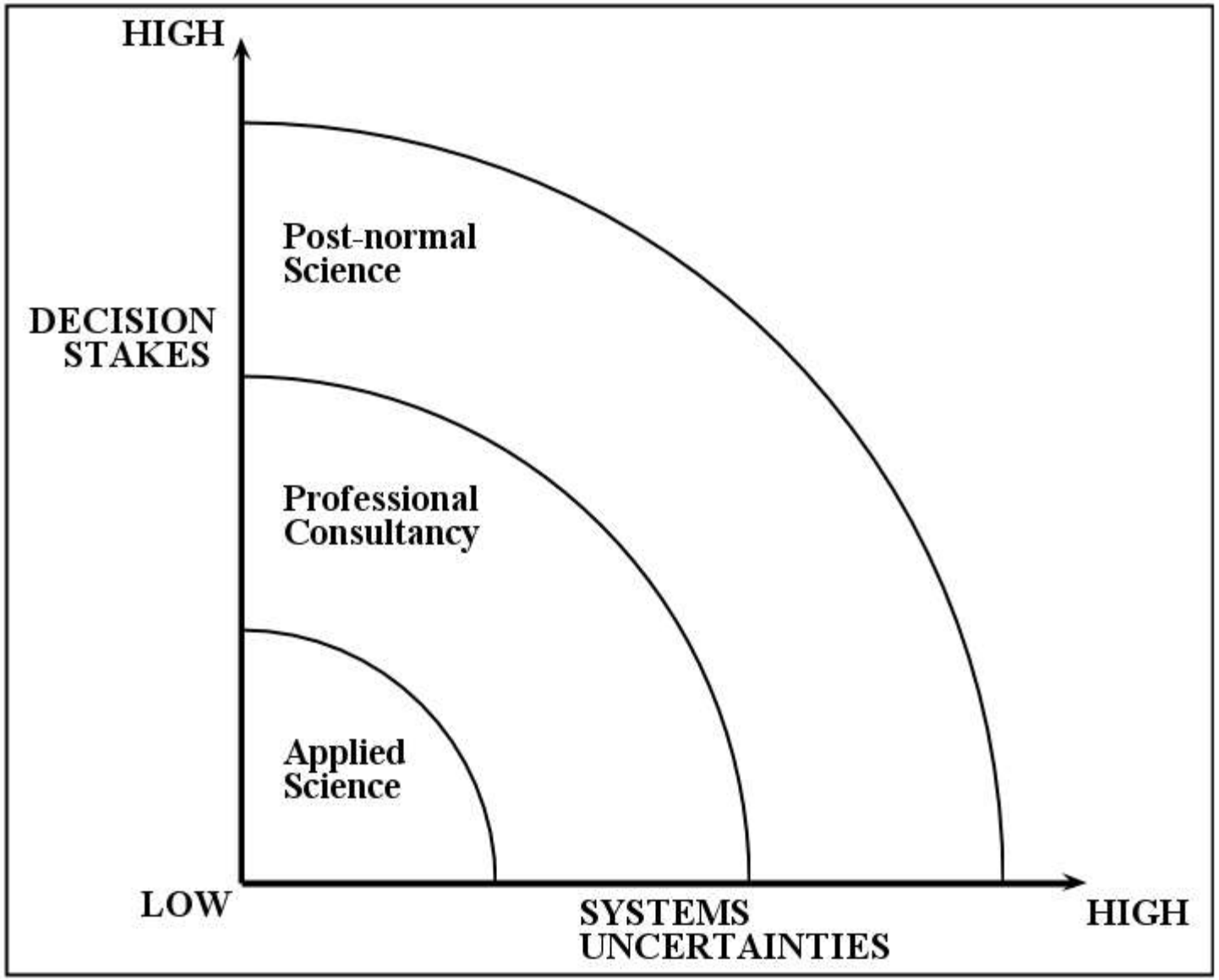
Post normal science



Funtowicz, S. and Ravetz, J., 1993. "Science for the post-normal age", Futures, 31(7): 735-755.

Funtowicz, S.O. and Ravetz, J.R. (1994). The worth of a songbird: Ecological economics as a post-normal science. Ecological Economics 10(3), 197-207.

… an approach for the use of science on issues where “facts are uncertain, values in dispute, stakes high and decisions urgent”

“the stage where we are today, where all the comfortable assumptions about science, its production and its use, are in question”

https://en.wikipedia.org/wiki/Post-normal_science

“… an inclusive set of robust insights more than as an exclusive fully structured theory or field of practice”

… a lens to see at the science-policy-technology interfaces with a hunch for context, purpose, assumptions, expectations, power relations, and for the non separability of facts and values

https://en.wikipedia.org/wiki/Post-normal_science

PNS's extended peer community

Participation: **PNS's extended peer community**

Extension to

1) more than one discipline

2) to lay actors, taken to be all those with stakes, or an interest (Why? Ask to Paul Feyerabend in Against Method) – including investigative journalism and whistle blowers.

Feyerabend, Paul (1975). Against method. Verso Publisher.

PNS's extended peer community

Inspiration: 'popular epidemiology', 'housewife epidemiology', early evidence-based medicine (the Cochrane collaboration), and the total quality management ideas of W. Edwards Deming, in particular quality circles.

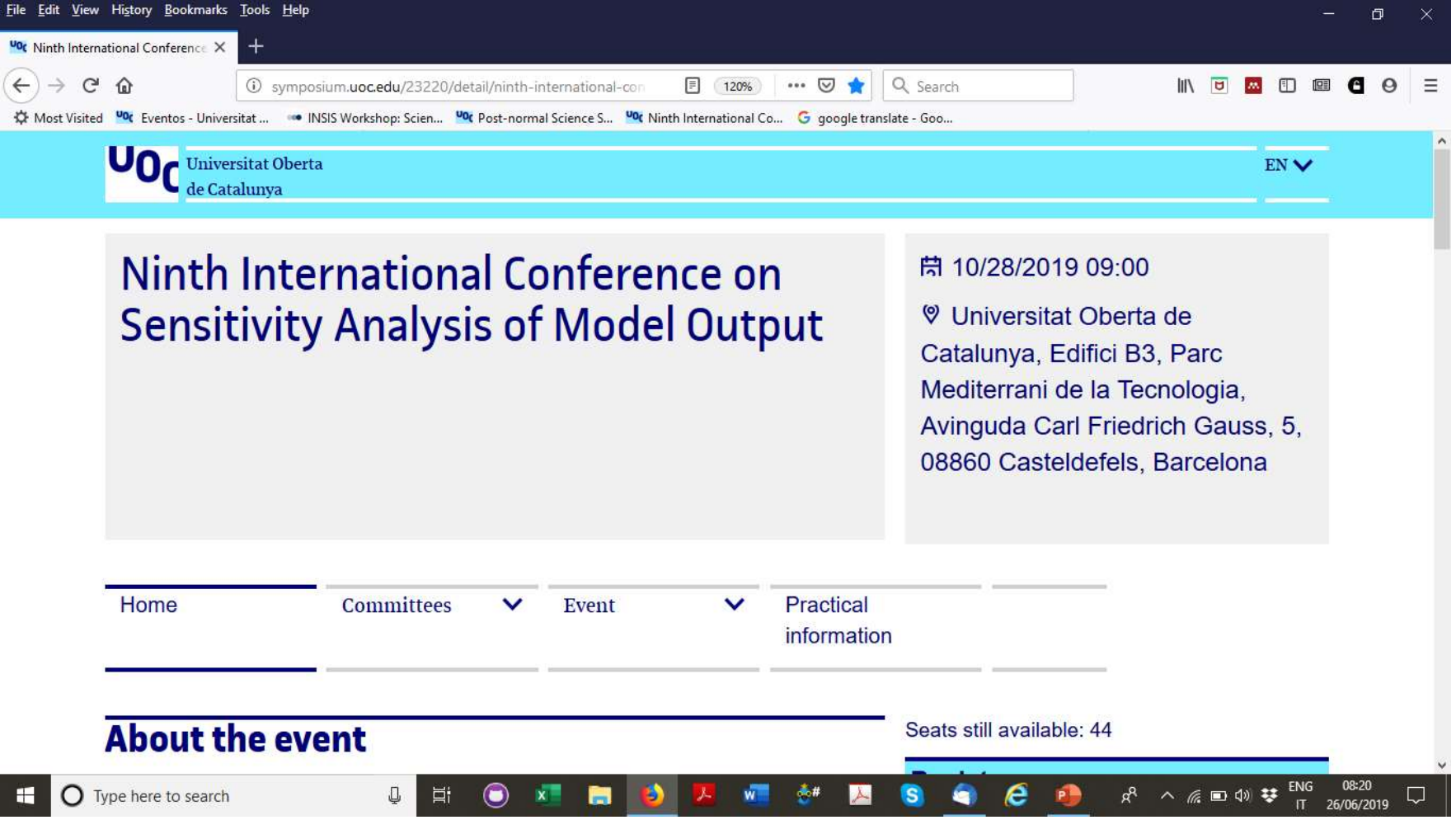
Phil Brown, 1997, Popular Epidemiology Revisited, Current Sociology, Volume: 45 issue: 3, page(s): 137-156.

PNS's extended peer community

The extension of the peer community is not only ethically fair or politically correct – it enhances quality, see Brian Wynne & Cumbrian sheep farmers' against scientist and authorities in the relation to the Chernobyl radioactive fallout

Wynne, B. (1992). Misunderstood misunderstanding: social identities and public uptake of science. Public Understanding of Science, 1, 281–304.

November 18-20 2019,
Barcelona



October 28-30 2019, Barcelona

The End

@andreasaltelli

Some examples:

Sensitivity auditing: the OECD PISA study

Do PISA data justify PISA-based education policy?

International Journal of Comparative Education and Development
Vol. 19 No. 1, 2017
pp. 1-17

2396-7404
DOI 10.1108/IJCED-12-2016-0023

THE CONVERSATION

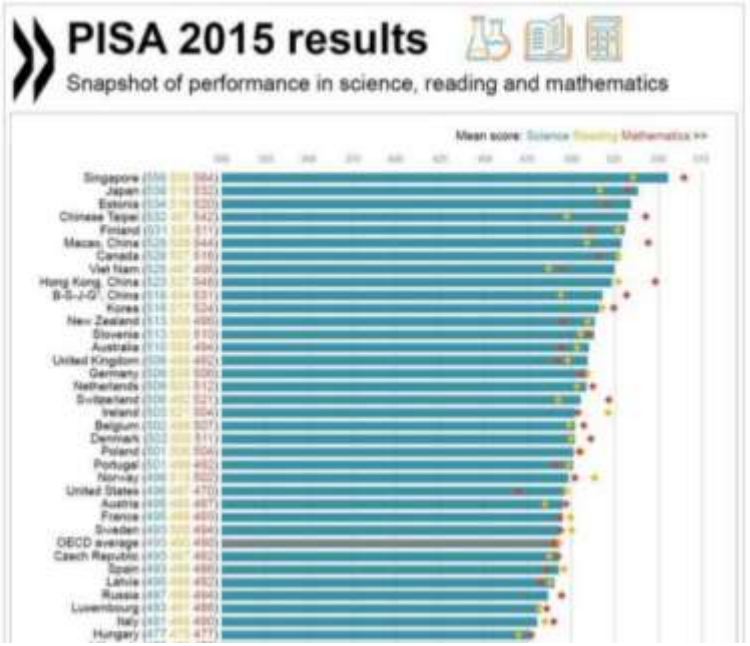
Academic rigour, journalistic flair

Arts + Culture | Business + Economy | Cities | Education | Environment + Energy | FactCheck | Health + Medicine | Politics + Society | Science + Technology

International PISA tests show how evidence-based policy can go wrong

June 12, 2017 3.55pm AEST

Chemistry class at the Dong Tien Secondary School, Thai Nguyen Province, Vietnam. Asian Development Bank/flickr, CC BY-SA



A condensed version of the article

With PISA the OECD gained the centre-stage in the international arena on education policies, which led to important controversies

http://www.theguardian.com/education/2014/may/06/oecd-pisa-tests-damaging-education-academics

theguardian

OECD and Pisa tests are damaging education worldwide - academics

In this letter to Dr Andreas Schleicher, director of the OECD's Programme for International Student Assessment, academics from around the world express deep concern about the impact of Pisa tests and call for a halt to the next round of testing

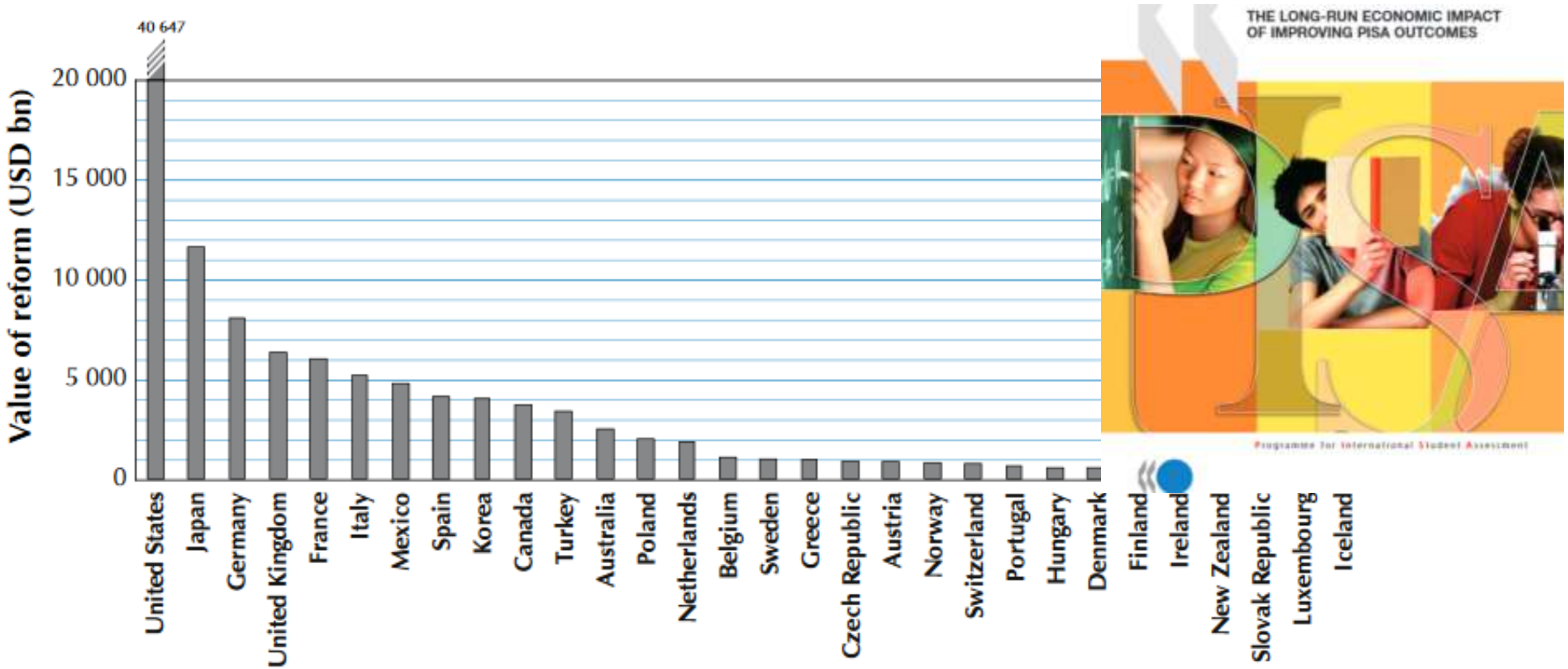
School children in Sichuan province in China. Academics say the OECD should develop alternatives to league tables and find more meaningful ways of reporting assessment, taking account of different cultures. Photograph: James Zeng Huang/Corbis Sygma

Critical remarks by the 80 signatories of the letter:

- Flattening of curricula (exclusion of subjects)
- Short-termism (teaching to the test)
- Promoting "life skills to function in knowledge societies"
- Stressing the student
- … ➔ Stop the test!
- A more participatory run of the study would be advisable

Figure 1

Present value of Scenario I (improve student performance in each country by 25 points on the PISA scale) in billion USD (PPP)



Note: Discounted value of future increases in GDP until 2090 due to reforms that improve student performance in each

http://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/thehighcostofloweducationalperformance.htm

PISA's daring quantifications:

"If every EU Member State achieved an improvement of 25 points in its PISA score (which is what for example Germany and Poland achieved over the last decade), the GDP of the whole EU would increase by between 4% and 6% by 2090; such an 6% increase would correspond to 35 trillion Euro"

Woessmann, L. (2014), "The economic case for education", EENEE Analytical Report 20, European Expert Network on Economics of Education (EENEE), Institute and University of Munich.

Our study identifies both technical and normative issues:

1) Non response bias (what students are excluded; PISA non-response for England: the bias turned out to be twice the size of the OECD declared standard error in 2003.

2) Non open data, which makes SA impossible

Our study identifies both technical and normative issues:

3) Flattening curricula (do all countries wish to prosper by becoming knowledge societies?)
4) Power implications: power in the use of evidence. OECD (unelected officers and scholars) becoming a global super-ministry of education

Some examples:

Sensitivity analysis: the case of the Stern review

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

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The case of Stern's Review – Technical Annex to postscript

Nicholas Stern, London School of Economics

William Nordhaus, University of Yale

Stern, N., Stern Review on the Economics of Climate Change. UK Government Economic Service, London, www.sternreview.org.uk.
Nordhaus W., Critical Assumptions in the Stern Review on Climate Change, SCIENCE, 317, 201-202, (2007).

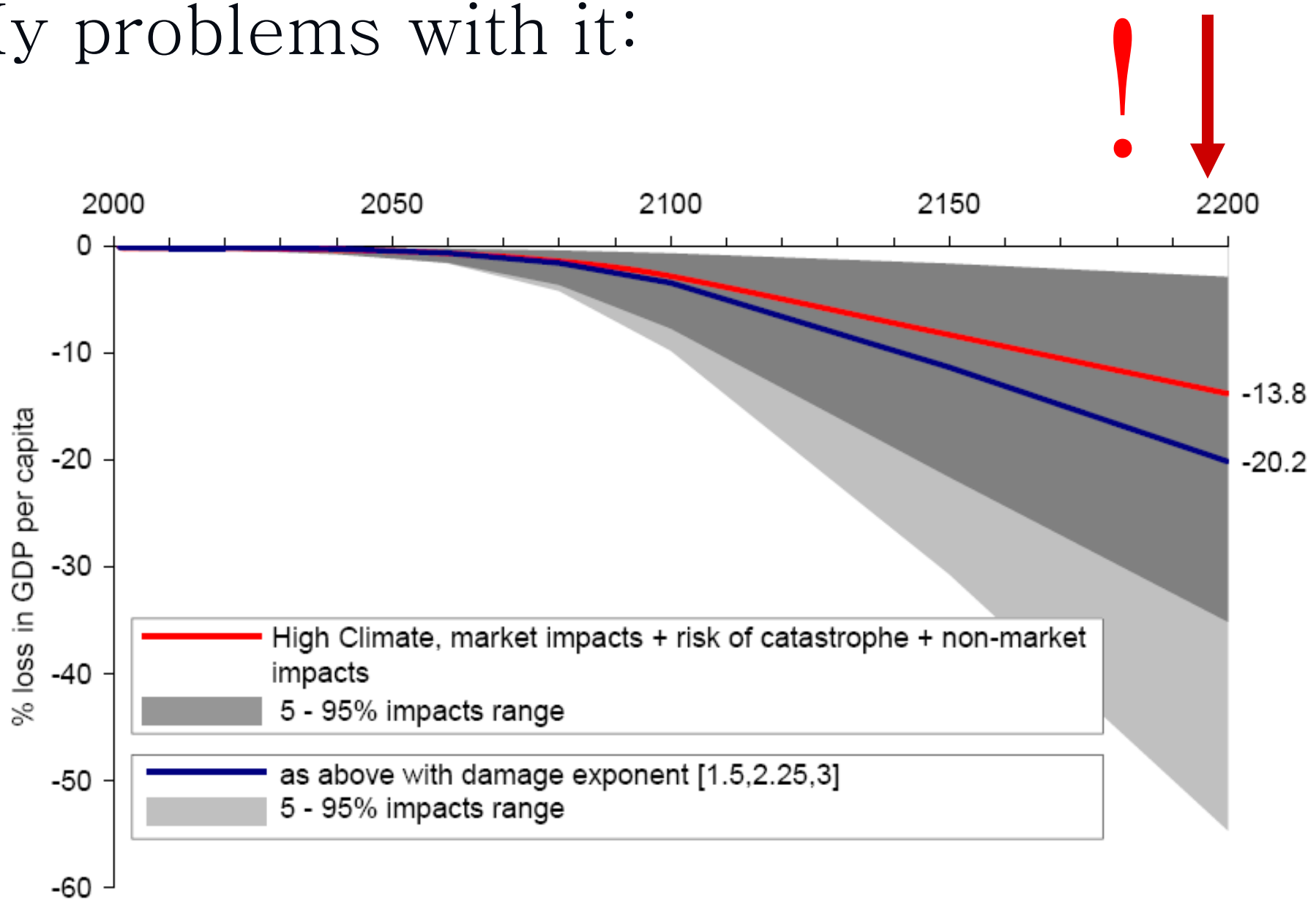
The Stern – Nordhaus exchange on *SCIENCE*

1) Nordhaus falsifies Stern based on 'wrong' range of discount rate

2) Stern's complements its review with a postscript: a sensitivity analysis of the cost benefit analysis

3) Stern infers: My analysis shows robustness'

My problems with it:

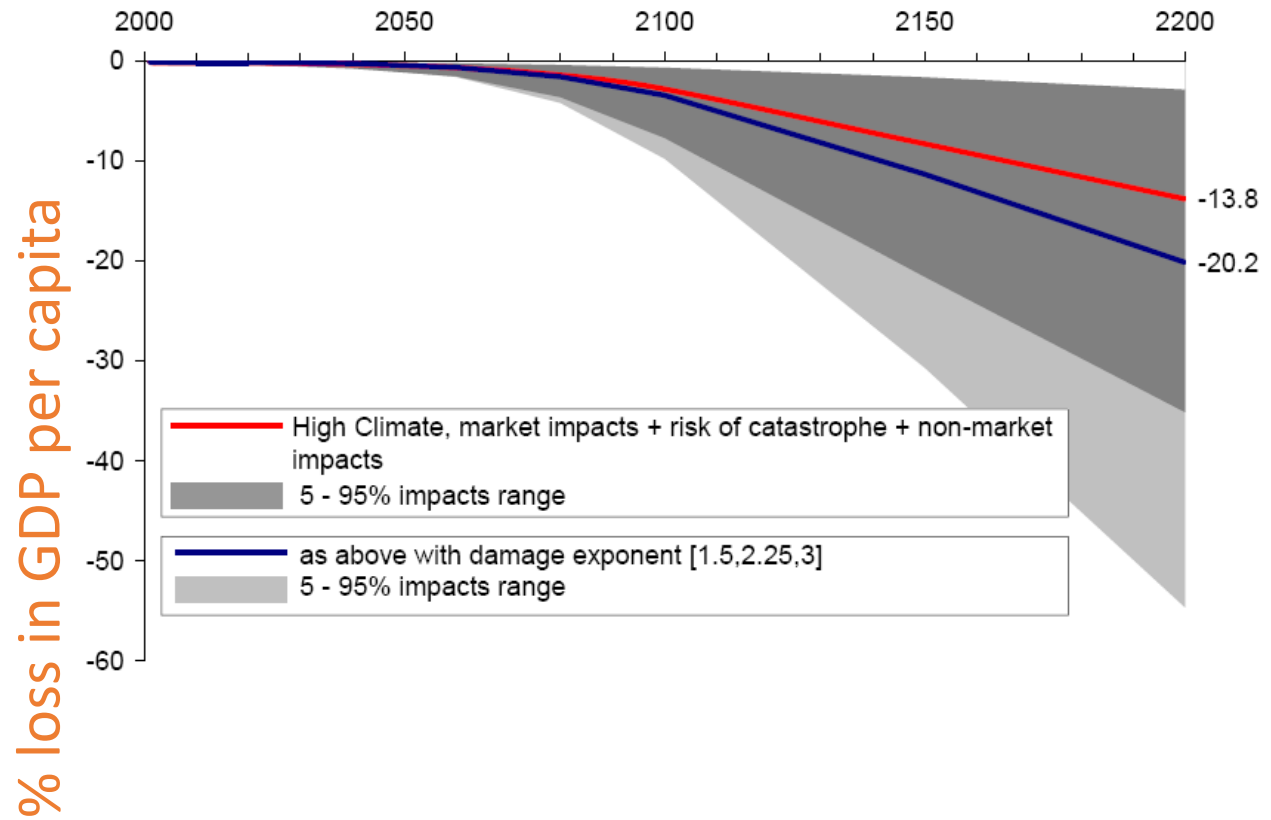


… but foremost Stern says:

changing assumptions → important effect

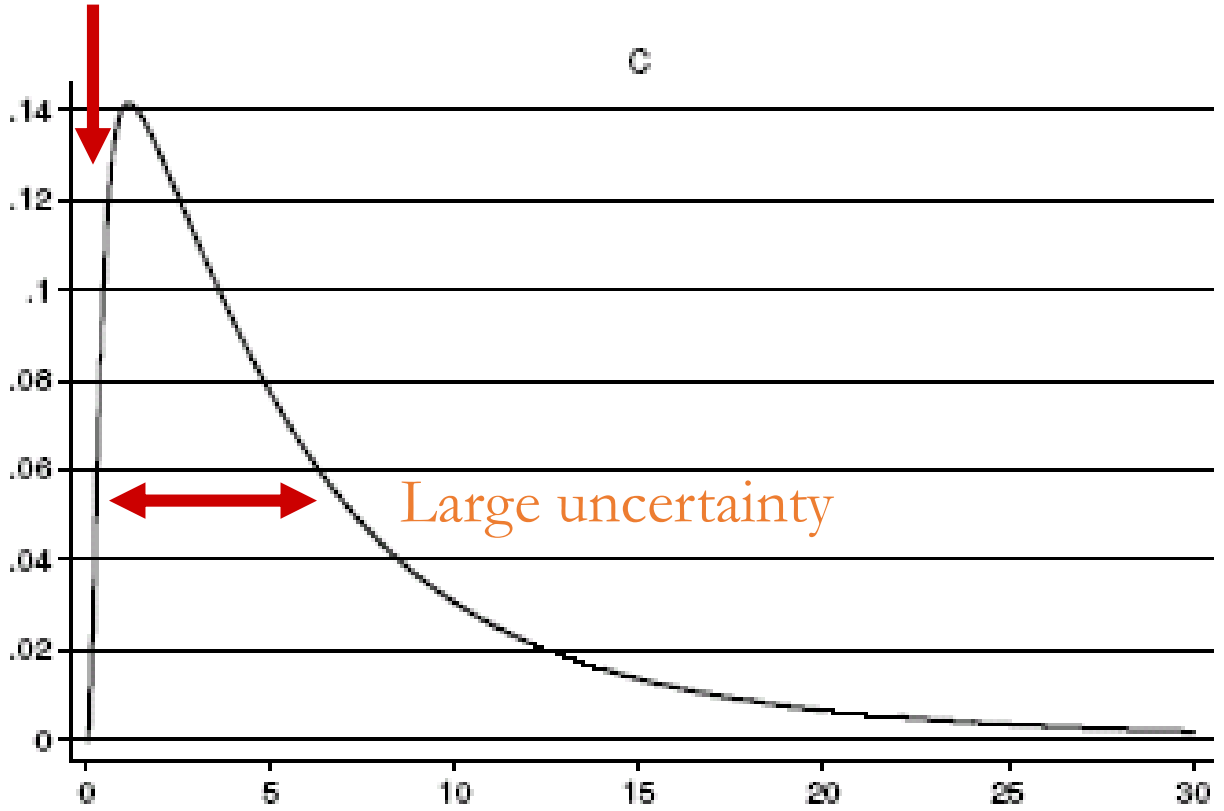
when instead he should admit that:

changing assumptions → all changes a lot

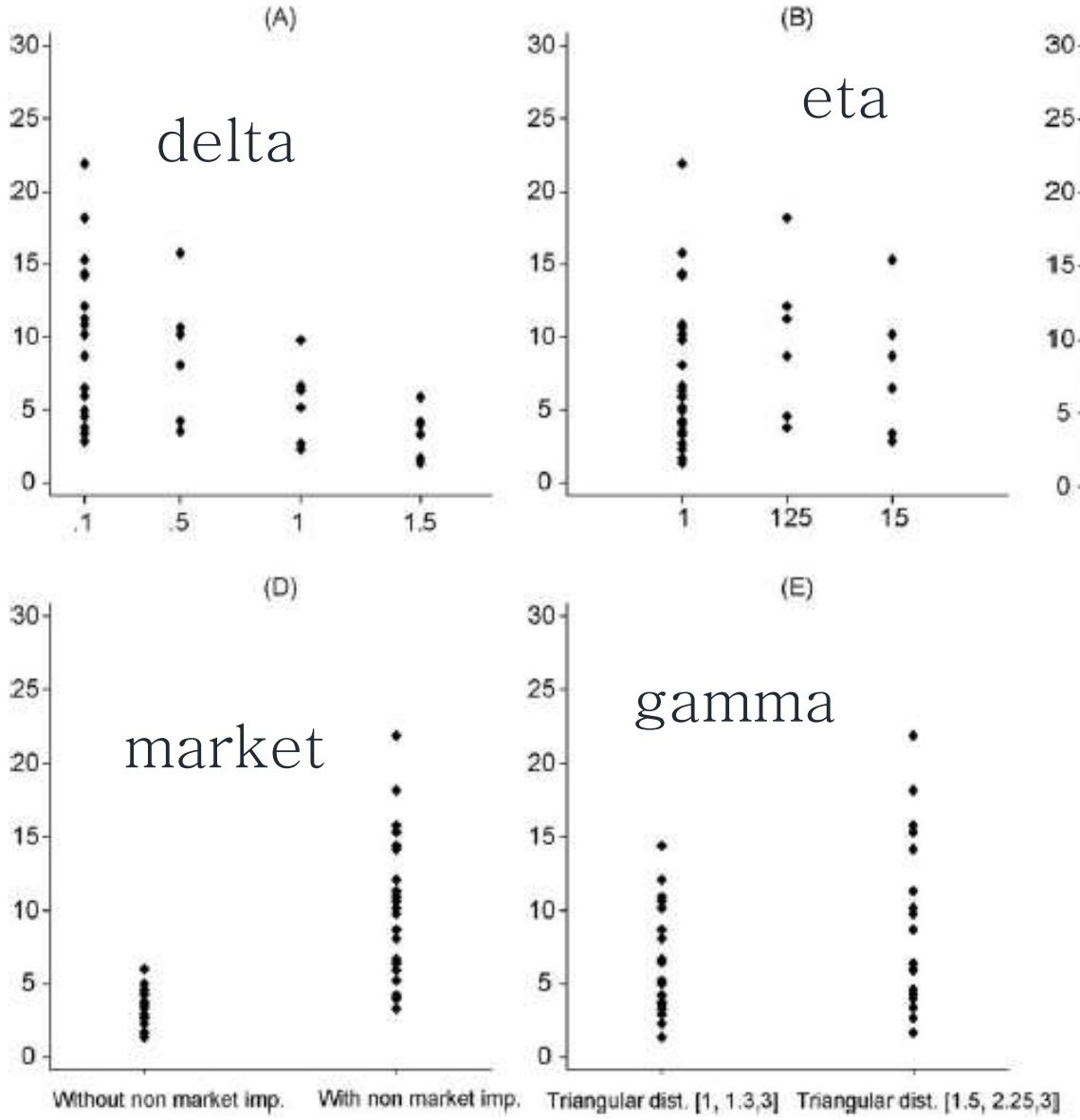


How was it done? A reverse engineering of the analysis

Missing points

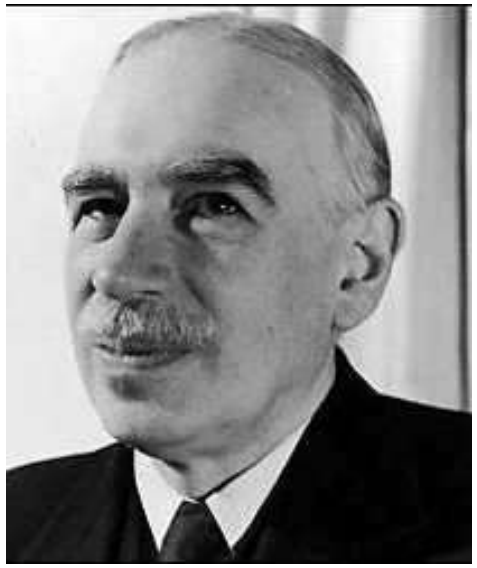


% loss in GDP per capita



Sensitivity analysis, also by reverse engineering

Same criticism applies to Nordhaus – both authors frame the debate around numbers which are …



… precisely wrong

From: Saltelli, A., D'Hombres, 2010, Sensitivity analysis didn't help. A practitioner's critique of the Stern review, *GLOBAL ENVIRONMENTAL CHANGE*, 20, 298-302.

The End

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Practicum

Grade a set of questions using a Likert scale

Likert scale

5. Strongly agree
4. Agree
3. Neutral
2. Disagree
1. Strongly disagree

A. Our duty is to provide objective numbers to policy makers. A cost benefit analysis is useful to make sure that taxpayer money is well spent.
B. Given proper statistical tools it is always possible to arrive at a number quantifying our present state of knowledge.
C. Numbers should be objective and not the result of 'stealth advocacy'.
D. Numbers can convey a misleading impression of accuracy and precision.
E. The analyst should strive to highlight the difference between risk and uncertainty.
F. The analyst should strive to identify different values underpinning different framing of the issue.

Practicum in sensitivity auditing

"What follows is a hypothetical executive summary from an imagined Food and Agriculture Organization (FAO) report on the state of the world's food systems, written from the perspective of the 2050s"

https://www.thesolutionsjournal.com/article/pathways-leading-sustainable-healthy-global-food-system/

Executive Summary: FAO State of World Agriculture in 2050 Draft Report

"[…]this FAO report presents evidence that the international food system of the second half of the 21st century is more sustainable than the food system of the late 20th or early 21st centuries.

[…] today more people are being fed on less land and agriculture is requiring fewer inputs"

Executive Summary: FAO State of World Agriculture in 2050 Draft Report

"[…] despite there being 10 billion people on the planet, today agriculture requires 438 million hectares* less land than it did in 2015, yet produces more adequate nutrition for all."

*Authors' estimate

This [438 Mha] figure was arrived at by assuming that:

- Agriculture shifts away from over production of cereals, oils, and sugars, but increases fruit and vegetables;
- Agricultural yields increase ~1%/y between now and 2050.
- Protein consumption shifts from 86% animals and 14% plants to 50% animal and 50% plant.

"Please contact the authors for references etc. pertaining to these calculations"

END

Our study:

- Gain in number of hectares: three significant digits (438 millions)?

- Balancing hectares growth and population growth (our computation) results in no change in food per capita at planetary scale.

Our study:

- Neglect of diminishing returns and ecosystem stress (fertilizers, pesticides)
- More adults (higher caloric intake) in 2050 population
- Can one educate citizens globally? The case of tobacco

In conclusion the

“mismatch between what the world needed for everyone to enjoy a nutritious diet and what the world was actually producing”

is the substitution of a political problem with a technical one

Food ethics (2017) 1:173–179
DOI 10.1007/s41055-017-0020-6

DISCUSSION PAPER

Problematic Quantifications: a Critical Appraisal of Scenario Making for a Global 'Sustainable' Food Production

Andrea Saltelli[1,2,3] · **Samuele Lo Piano**[1]

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Reformation or resistance?