

Present challenges in sensitivity analysis

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SAMO2016 La Reunion (FR)

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Sign and donate. What these people are doing is unique. twitter.com/Jeroen_vdSluij...



21/11



andrea saltelli

@AndreaSaltelli

Lovely (also in the sense of 'of love') piece by an Italian scholar [@robertocalasso](https://twitter.com/robertocalasso):

[nybooks.com/articles/2016/...](https://nybooks.com/articles/2016/)



Embed

View on Twitter

sensitivity analysis, sensitivity auditing, science for policy, impact assessment

Andrea
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HOME ABOUT ME



= more material on my web site

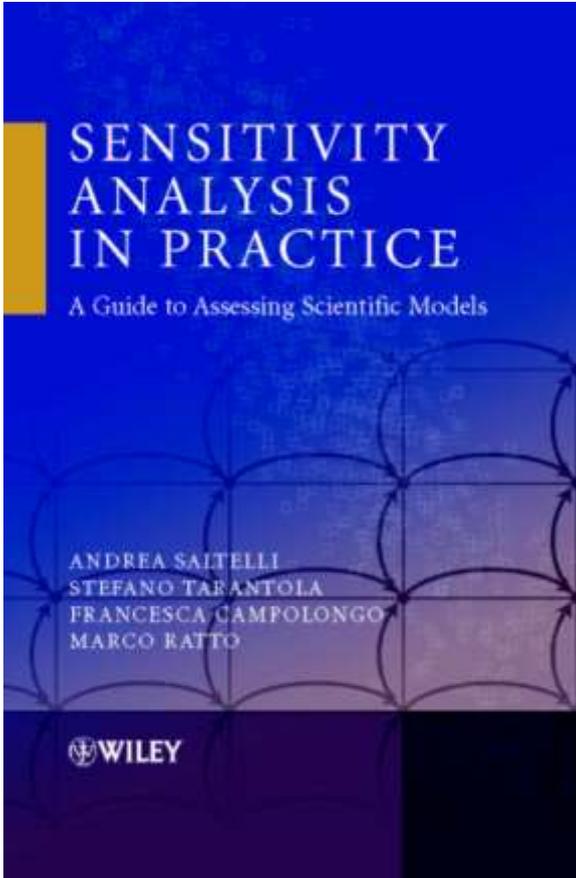


= more material on Wikipedia

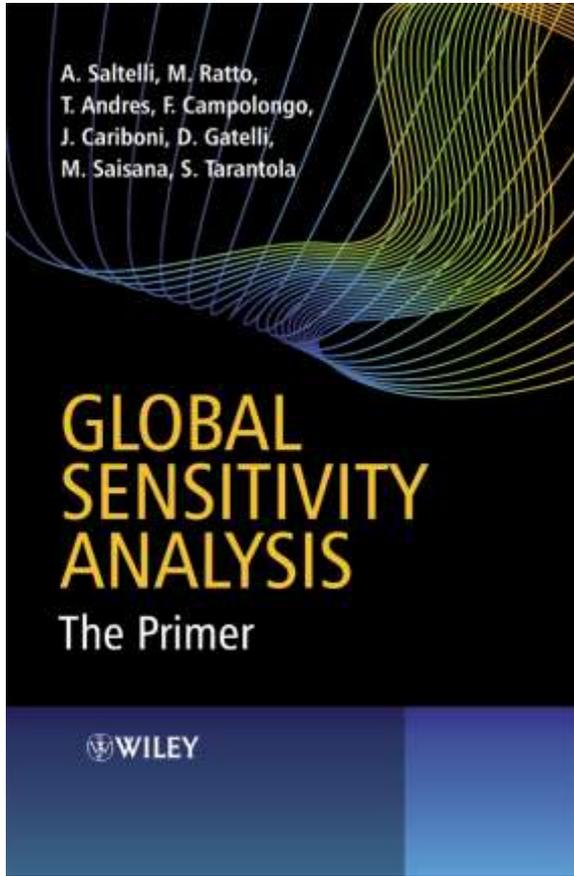
What happened since Nice 2013?



Sensitivity analysis books available on **Library Genesis^{1M}**



+



=



Sensitivity analysis
acknowledged as
necessary

Office for the Management and Budget, 2006

Environmental Protection Agency, 2009

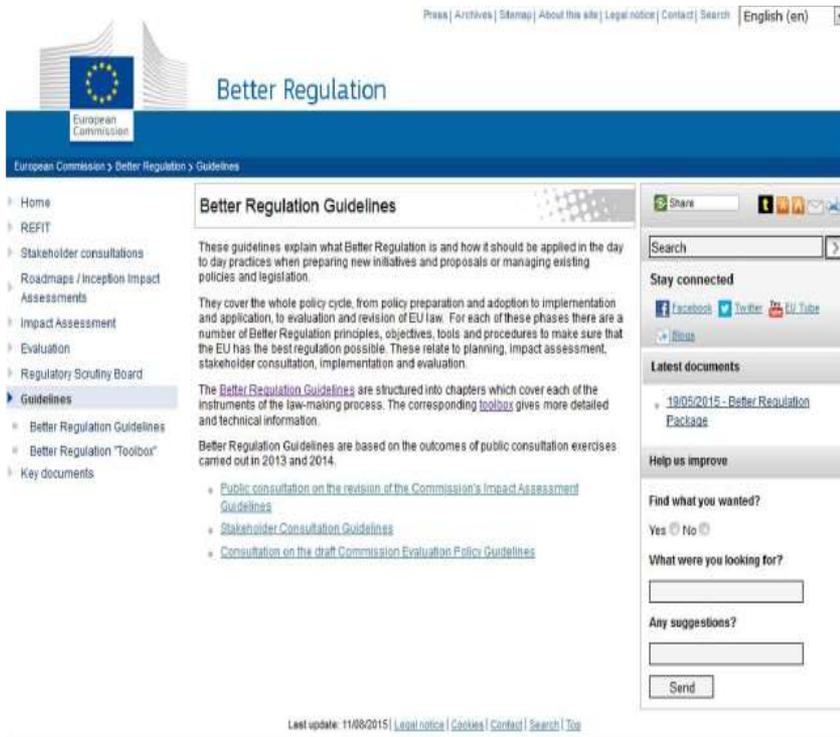
European Commission, 2015

EPA, 2009, March. Guidance on the Development, Evaluation, and Application of Environmental Models. Technical Report EPA/100/K-09/003. Office of the Science Advisor, Council for Regulatory Environmental Modeling, <http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1003E4R.PDF>, Last accessed December 2015.

EUROPEAN COMMISSION, Better regulation toolbox, appendix to the Better Regulation Guidelines, Strasbourg, 19.5.2015, SWD(2015) 111 final, COM(2015) 215 final, http://ec.europa.eu/smart-regulation/guidelines/docs/swd_br_guidelines_en.pdf.

OMB, Proposed risk assessment bulletin, Technical report, The Office of Management and Budget's – Office of Information and Regulatory Affairs (OIRA), January 2006, https://www.whitehouse.gov/sites/default/files/omb/assets/omb/inforeg/proposed_risk_assessment_bulletin_010906.pdf, pp. 16–17, accessed December 2015.

<http://ec.europa.eu/smart-regulation/>



The screenshot shows the 'Better Regulation Guidelines' page on the European Commission website. The page features a blue header with the European Commission logo and the title 'Better Regulation'. A navigation menu on the left lists various sections, with 'Guidelines' selected. The main content area contains the title 'Better Regulation Guidelines' and a brief introduction. Below this, there are three paragraphs of text explaining the guidelines and their structure. A list of links is provided at the bottom of the main content area. On the right side, there are several utility boxes: 'Share' with social media icons, a search bar, 'Stay connected' with social media links, 'Latest documents' with a link to a 2015 package, 'Help us improve', and a feedback form with 'Yes/No' radio buttons, a text input field, and a 'Send' button. The footer includes the text 'Last update: 11/08/2015' and links for 'Legal notice', 'Cookies', 'Contact', and 'Search'.

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European Commission

Better Regulation

European Commission > Better Regulation > Guidelines

Home

REFIT

Stakeholder consultations

Roadmaps / Inception Impact Assessments

Impact Assessment

Evaluation

Regulatory Scrutiny Board

Guidelines

Better Regulation Guidelines

Better Regulation "Toolbox"

Key documents

Better Regulation Guidelines

These guidelines explain what Better Regulation is and how it should be applied in the day to day practices when preparing new initiatives and proposals or managing existing policies and legislation.

They cover the whole policy cycle, from policy preparation and adoption to implementation and application, to evaluation and revision of EU law. For each of these phases there are a number of Better Regulation principles, objectives, tools and procedures to make sure that the EU has the best regulation possible. These relate to planning, impact assessment, stakeholder consultation, implementation and evaluation.

The [Better Regulation Guidelines](#) are structured into chapters which cover each of the instruments of the law-making process. The corresponding [toolbox](#) gives more detailed and technical information.

Better Regulation Guidelines are based on the outcomes of public consultation exercises carried out in 2013 and 2014.

- [Public consultation on the revision of the Commission's Impact Assessment Guidelines](#)
- [Stakeholder Consultation Guidelines](#)
- [Consultation on the draft Commission Evaluation Policy Guidelines](#)

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19/05/2015 - Better Regulation Package

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EUROPEAN COMMISSION

Better Regulation "Toolbox"

4. SENSITIVITY AND UNCERTAINTY ANALYSES

Page 391

- Six steps for a global SA:
 1. Select one output of interest;
 2. Participatory step: discuss which input may matter;
 3. Participatory step (extended peer review): define distributions;
 4. Sample from the distributions;
 5. Run (=evaluate) the model for the sampled values;
 6. Obtain in this way both the uncertainty of the prediction and the relative importance of variables.

Sensitivity auditing also
acknowledged

Sensitivity auditing



- Originates from uncertainty & sensitivity analysis
- Addresses model-based evidence used for policy

Saltelli, A., Guimarães Pereira, Â., Van der Sluijs, J.P. and Funtowicz, S., 2013, What do I make of your latinorum? Sensitivity auditing of mathematical modelling, *Int. J. Foresight and Innovation Policy*, 9, 2/3/4, 213–234.

Saltelli, A., Funtowicz, S., When all models are wrong: More stringent quality criteria are needed for models used at the science-policy interface, *Issues in Science and Technology*, Winter 2014, 79-85.

<http://issues.org/30-2/andrea/>



EC guidelines: what do they about sensitivity auditing ?

The screenshot shows the 'Better Regulation Guidelines' page on the European Commission website. The page features a blue header with the European Commission logo and the text 'Better Regulation'. Below the header, there is a navigation menu on the left with options like 'Home', 'REFIT', 'Stakeholder consultations', 'Roadmaps / Inception Impact Assessments', 'Impact Assessment', 'Evaluation', 'Regulatory Scrutiny Board', and 'Guidelines'. The main content area is titled 'Better Regulation Guidelines' and contains several paragraphs of text explaining the guidelines. On the right side, there are social media sharing options, a search bar, and a 'Stay connected' section with links to Facebook, Twitter, and YouTube. Below that, there is a 'Latest documents' section with a link to '19/05/2015 - Better Regulation Package'. At the bottom of the page, there is a footer with the text 'Last update: 11/08/2015 | Legal notice | Cookies | Contact | Search | Top'.

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.

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

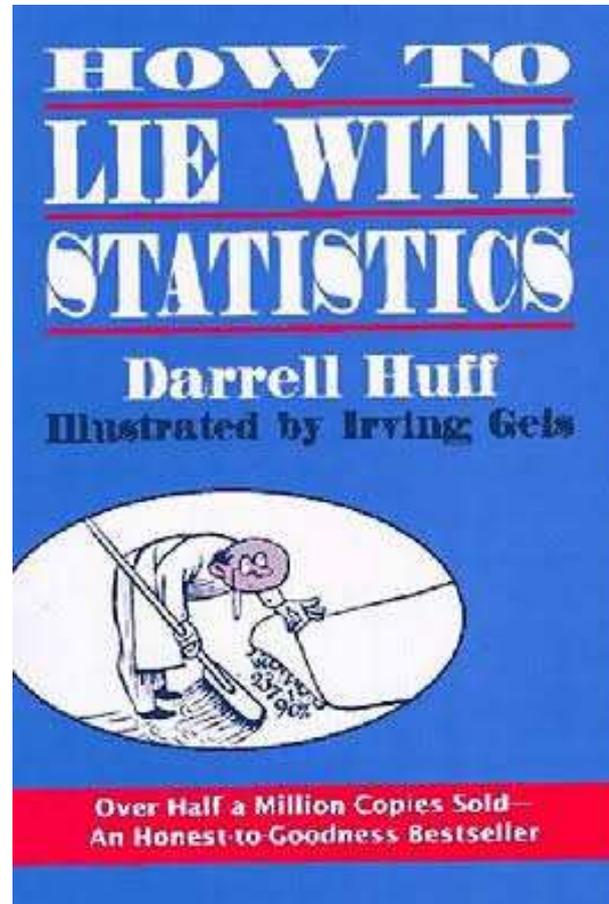
“In general sensitivity auditing stresses the idea of honestly communicating the extent to which model results can be trusted, taking into account as much as possible all forms of potential uncertainty, and to anticipate criticism by third parties.”

p. 393

“In particular, one should avoid giving the impression of false confidence by “quantification at all costs”. In some cases there is simply not enough data, or the process is too complex, to give a meaningful quantitative prediction.”

Problematic sensitivity analyses

Can I lie with sensitivity analysis as I can lie with statistics?



Saltelli, A., Annoni P., 2010, How to avoid a perfunctory sensitivity analysis, Environmental Modeling and Software, 25, 1508-1517.



OAT is still the most used technique. Out of every 100 papers with SA only 4 are 'global' (non-OAT)



Contents lists available at ScienceDirect

Science of the Total Environment

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



Trends in sensitivity analysis practice in the last decade

Federico Ferretti ^{a,*}, Andrea Saltelli ^{b,d}, Stefano Tarantola ^c

^a European Commission, Joint Research Centre (JRC), Unit of Econometrics and Applied Statistics, via Enrico Fermi 2749 TP 361, Ispra, 21027 VA, Italy

^b Centre for the Study of the Sciences and the Humanities (SVT), University of Bergen (UIB), Spain

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^d Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona, Spain

Ferretti, F., Saltelli A., Tarantola, S., 2016, Trends in Sensitivity Analysis practice in the last decade, Science of the Total Environment, <http://dx.doi.org/10.1016/j.scitotenv.2016.02.133>

Andrea
Saltelli

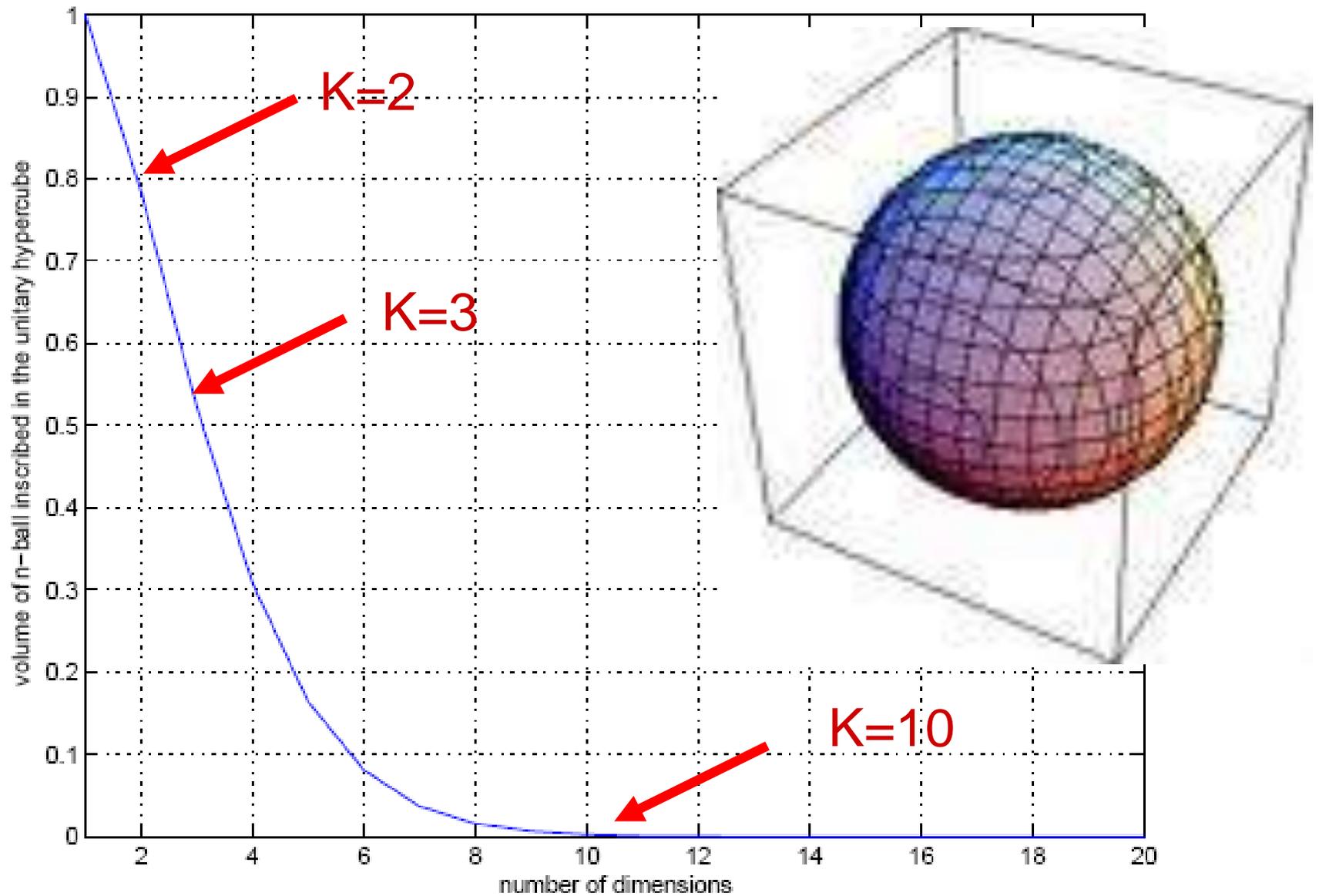
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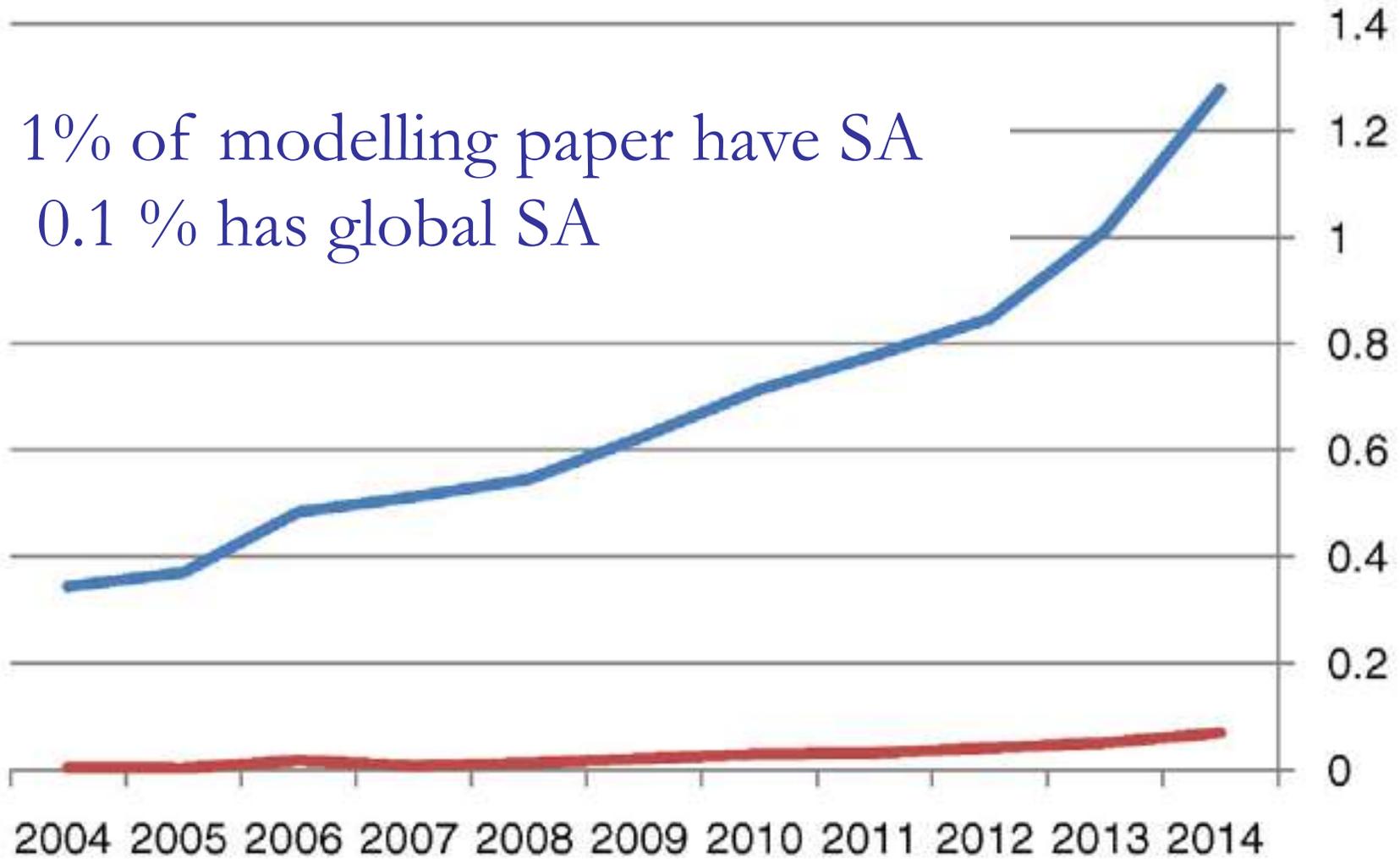
OAT in 10 dimensions puts zero points in a portion of the input space equal to 99.75% of the input space



OAT in k dimensions



> 1% of modelling paper have SA
< 0.1 % has global SA



— TOT_SAVTOT_MOD (%)
— TOT_GSA/TOT_MOD (%)

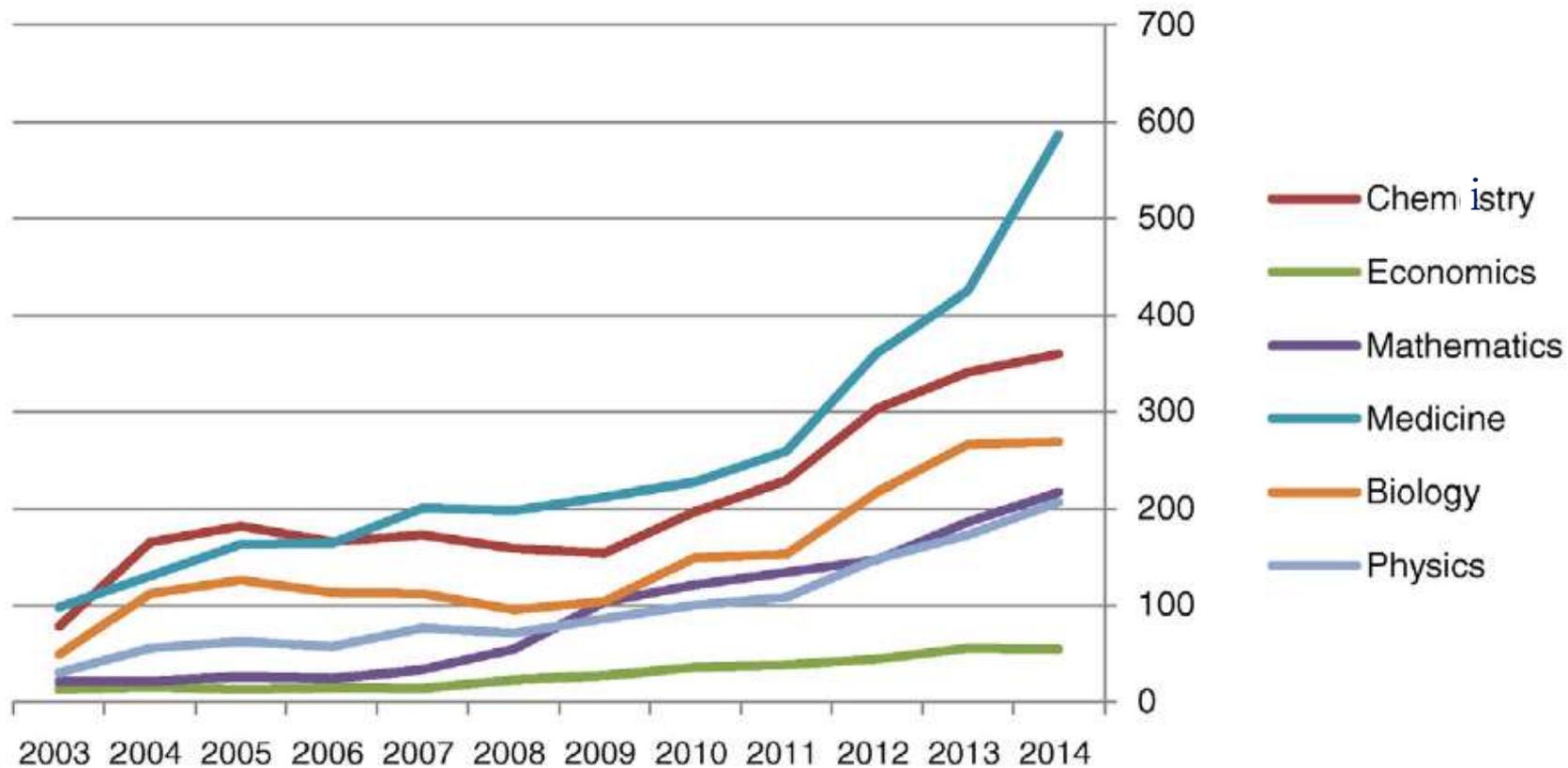


Fig. 4. GSA in the different scientific domains.

Problematic quantifications in statistics

REPRODUCIBILITY

Statisticians issue warning on *P* values

Statement aims to halt missteps in the quest for certainty.

“Misuse of the *P* value — a common test for judging the strength of scientific evidence — is contributing to the number of research findings that cannot be reproduced”



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**AMERICAN STATISTICAL ASSOCIATION RELEASES STATEMENT ON
STATISTICAL SIGNIFICANCE AND P-VALUES**

*Provides Principles to Improve the Conduct and Interpretation of Quantitative
Science*

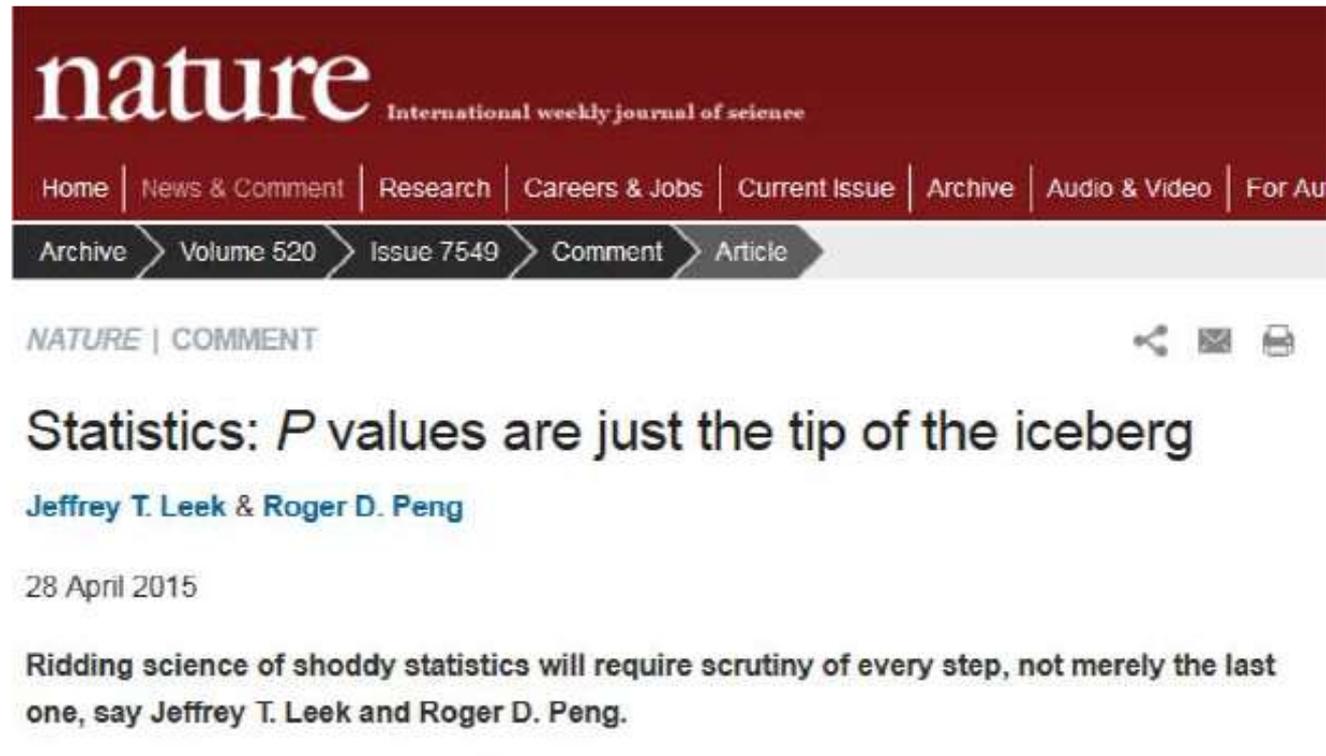
March 7, 2016

... and twenty ‘dissenting’ commentaries

Wasserstein, R.L. and Lazar, N.A., 2016. ‘The ASA's statement on p-values: context, process, and purpose’, *The American Statistician*, DOI:10.1080/00031305.2016.1154108.

See also Christie Aschwanden at <http://fivethirtyeight.com/features/not-even-scientists-can-easily-explain-p-values/>

A loss of craft skills in statistics?



The image shows a screenshot of a web page from the journal Nature. The top navigation bar is dark red with white text for 'nature' and 'International weekly journal of science'. Below this is a secondary navigation bar with links for Home, News & Comment, Research, Careers & Jobs, Current Issue, Archive, Audio & Video, and For Authors. A breadcrumb trail below the navigation bar shows 'Archive > Volume 520 > Issue 7549 > Comment > Article'. The main content area has a light gray background. On the left, it says 'NATURE | COMMENT'. On the right, there are icons for sharing, email, and printing. The article title is 'Statistics: *P* values are just the tip of the iceberg' in a large, bold, black font. Below the title, the authors 'Jeffrey T. Leek & Roger D. Peng' are listed in a smaller, blue font. The date '28 April 2015' is shown below the authors. A short abstract or lead sentence follows: 'Ridding science of shoddy statistics will require scrutiny of every step, not merely the last one, say Jeffrey T. Leek and Roger D. Peng.'

Leek J.T., and Peng, R.D., 2015, P values are just the tip of the iceberg, Nature, 520, p. 612.

Statistical and mathematical modelling are at the hearth of science for policy; yet alarm about malpractices.

New Scientist talks of “statistical sausage factory”

LEADER 13 April 2016

Science isn't as solid as it should be – but science can fix it

Unconscious biases and data-torturing are weakening our knowledge base – but unlike politicians and bankers, scientists aren't covering up their failings



Why so much science research is flawed – and what to do about it

Dodgy results are fuelling flawed policy decisions and undermining medical advances. They could even make us lose faith in science. **New Scientist** investigates



An alarming amount of research is flawed
Brett Ryder

**New
Scientist**

A new community for science

From Andrea Salielli, Jerome R. Ravetz and Silvio Funtowicz

We would like to complement your analysis of a crisis in science relating to studies that can't be replicated (16 April, p 5 and p 38). One of us, Jerome Ravetz, predicted in 1971 in his book *Scientific Knowledge and its Social Problems* that the system of internal quality control of science would not easily withstand the evolution toward big science.

Quality in science depends on the existence of a community of scholars linked by norms and standards, and willing to stand by these. The historian Philip Mirowski in *Science-Mart* (2011), fills in the blanks of Ravetz's analysis with details of how science's internal quality control system stalled when "market" replaced "community" as a unifying principle, driven by firms funding research.

The crisis has deep significance, since the contract between science and power is a basis of modernity. Science offers legitimacy to power via its guarantee of "truth". If trust collapses within the research sector, how can public trust be maintained for the many policy-relevant functions of science?

Reform will depend on the emergence of a new "polity" of science including citizen scientists who take responsibility for rooting out corruption of all sorts, scientist-citizens working primarily in the policy arena and concerned journalists and teachers. Issues of ethics and quality, previously largely restricted to coffee-time grumbles, now attract public debates and activist campaigns.

Bergen, Norway; Barcelona, Spain; and Oxford, UK

June 26, 2016

<https://www.newscientist.com/letter/mg23030791-600-7-a-new-community-for-science/>

Is there a crisis?



Sources 1:



THE RIGHTFUL PLACE OF SCIENCE: **SCIENCE ON THE VERGE**

CONTRIBUTORS

Alice Benessia
Silvio Funtowicz
Mario Giampietro
Ângela Guimarães Pereira
Jerome R. Ravetz
Andrea Saltelli
Roger Strand
Jeroen P. van der Sluijs



The Rightful Place of Science: Science on the Verge

Paperback – 20 Feb 2016

by [Andrea Saltelli](#) (Author), [Alice Benessia](#) (Author), & 7 more

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A crisis looms over the scientific enterprise. Not a day passes without news of retractions, failed replications, fraudulent peer reviews, or misinformed science-based policies.

Science in crisis: from the sugar scam to Brexit, our faith in experts is fading

September 27, 2016 4:43pm AEST



The
Economist

OCTOBER 19TH - 20TH 2013

economist.com

Washington's lawyer surplus
How to do a nuclear deal with Iran
Investment tips from Nobel economists
Junk bonds are back
The meaning of Sachin Tendulkar

HOW SCIENCE GOES WRONG.

99
Einsteinium

Unreliable research

Trouble at the lab

Scientists like to think of science as self-correcting. To an alarming degree, it is not

Oct 19th 2013 | From the print edition

 Timekeeper

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The crisis has ethical,
epistemological, methodological
and even metaphysical dimensions;



THE RIGHTFUL
PLACE OF SCIENCE:

SCIENCE ON THE VERGE

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Identified points of friction:

- paradigm of evidence-based policy
- use of science to produce implausibly precise numbers and reassuring techno-scientific imaginaries
- use of science to ‘compel’ decision by the sheer strength of ‘facts’



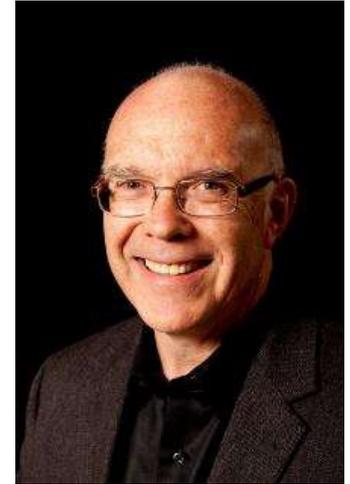
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- Generation of new data/ publications at an unprecedented rate
- Compelling evidence that the majority of these discoveries will not stand the test of time.



C. Glenn Begley



John P. A. Ioannides

Begley, C. G., and Ioannidis, J. P., 2015, Reproducibility in Science. Improving the Standard for Basic and Preclinical Research, *Circulation Research*, 116, 116-126, doi: 10.1161/CIRCRESAHA.114.303819

- Causes: failure to adhere to good scientific practice & the desperation to publish or perish.

In the book we have a different theory but ... read the book!



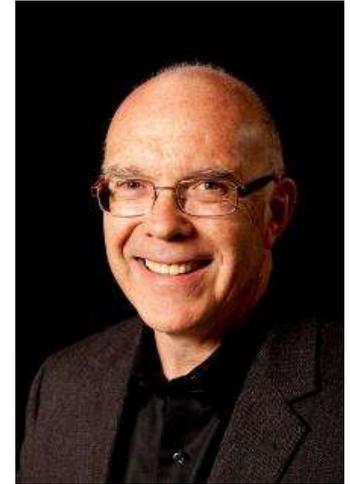
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C. Glenn Begley



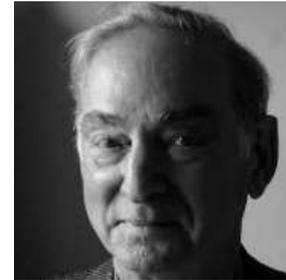
John P. A. Ioannides

Science/knowledge degenerates when it becomes a commodity for Ravetz (1971), Lyotard (1979) and Mirowski (2011).

Ravetz, J., 1971, *Scientific Knowledge and its Social Problems*, Oxford University Press, p. 22.

Lyotard, J.-F. 1979. *La Condition postmoderne. Rapport sur le savoir*, Paris : Minuit, Chapter 10.

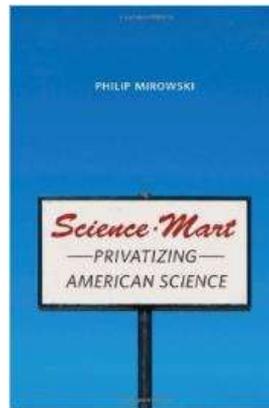
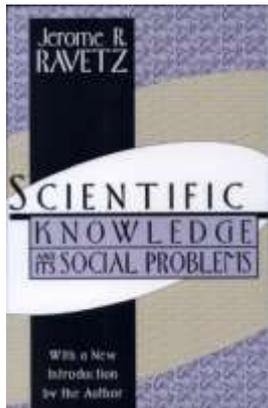
Mirowski, P. 2011. *Science-Mart: Privatizing American Science*, Harvard University Press.



Jerome R.
Ravetz



Jean-François
Lyotard



Philip
Mirowski

In economics see the ‘Mathiness’ discussion: blogs of Paul Romer, Judith Curry and Erik Reinert’s ‘scholasticism’ paper.

See <https://paulromer.net/mathiness/>

<https://judithcurry.com/2015/08/12/the-adversarial-method-versus-feynman-integrity-2/>

http://www.andreasaltelli.eu/file/repository/Full_Circle_scholasticism_2.pdf



Paul Romer



Judith Curry



Erik Reinert

Institutions charged with science advice choose to ignore the crisis

OECD publishing

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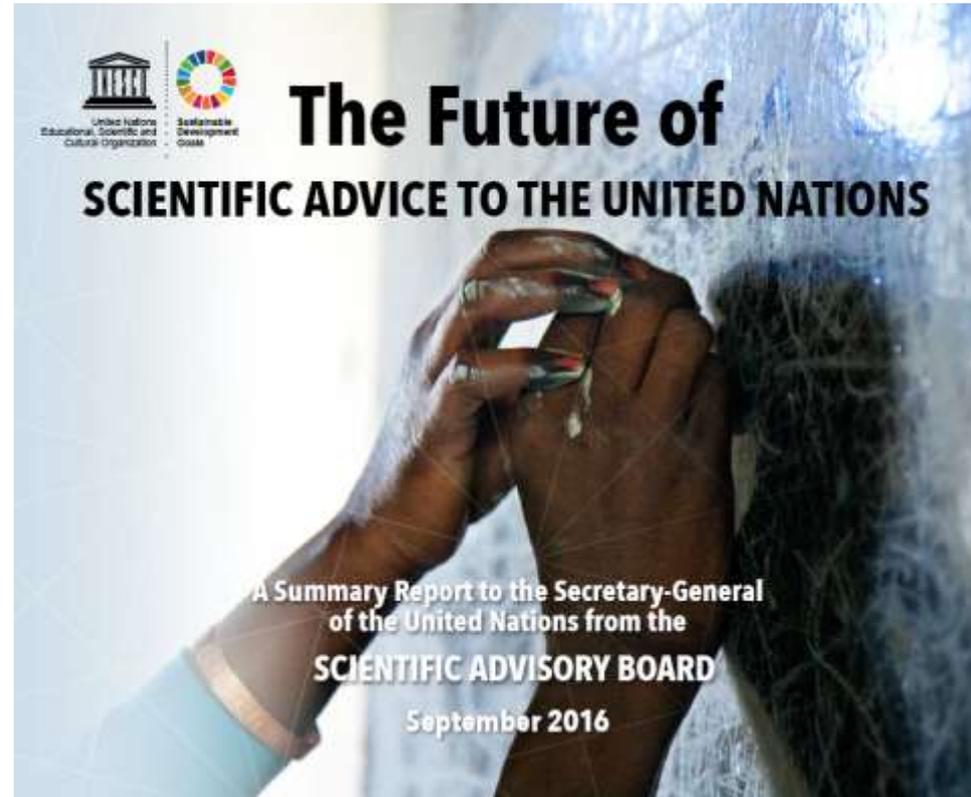
OECD (2015), "Scientific Advice for Policy Making: The Role and Responsibility of Expert Bodies and Individual Scientists", *OECD Science, Technology and Industry Policy Papers*, No. 21, OECD Publishing, Paris.
<http://dx.doi.org/10.1787/5js3311jcpwb-en>

OECD Science, Technology and Industry
Policy Papers No. 21

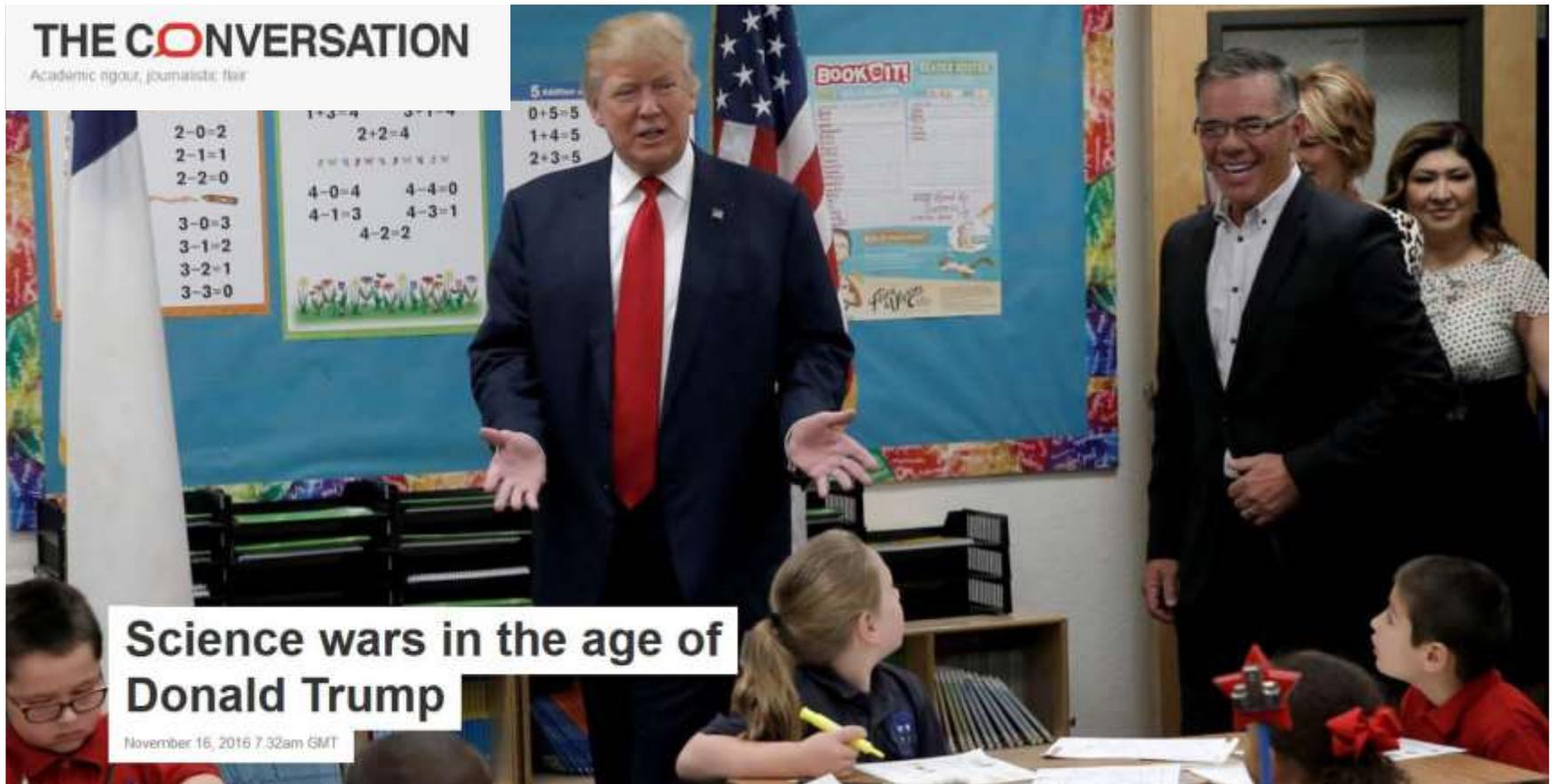
Scientific Advice for Policy Making

THE ROLE AND RESPONSIBILITY OF EXPERT
BODIES AND INDIVIDUAL SCIENTISTS

OECD



BREXIT and the election of D. Trump have unleashed a debate on post-truth, end of expertise, and ultimately a new season of science wars



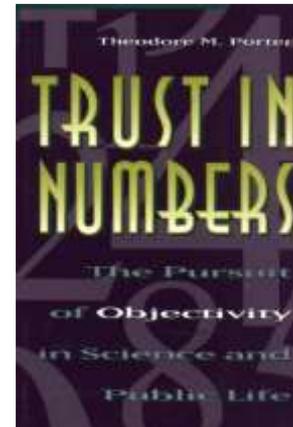
Andrea Saltelli and Silvio Funtowicz, Science wars in the age of Trump, November 16, 2016
<https://theconversation.com/science-wars-in-the-age-of-donald-trump-67594>

Quantification and trust

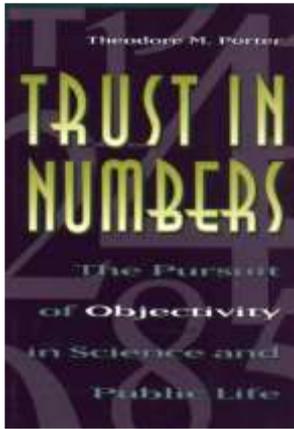
p. 8: “The appeal of numbers is especially compelling to bureaucratic officials who lack the mandate of a popular election, or divine right. Arbitrariness and bias are the most usual grounds upon which such officials are criticized. A decision made by the numbers (or by explicit rules of some other sort) has at least the appearance of being fair and impersonal.”



Theodor M. Porter

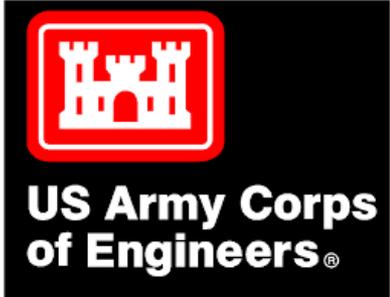


Theodore M. Porter, Trust in Numbers, The Pursuit of Objectivity in Science and Public Life, Princeton 1995

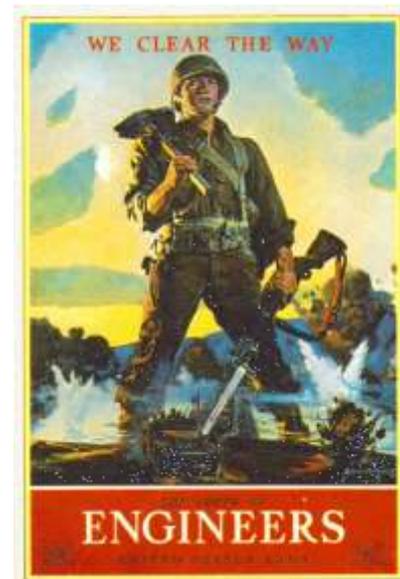


p. 8: “Scientific objectivity thus provides an answer to a moral demand for impartiality and fairness. Quantification is a way of making decisions without seeming to decide. Objectivity lends authority to officials who have very little of their own.”

Trust, authority and styles of quantification: two different stories



Porter's story: Quantification needs judgment which in turn needs trust ...without trust quantification becomes mechanical, a system, and 'systems can be played'.



Can sensitivity analysis and auditing play a role in all this?

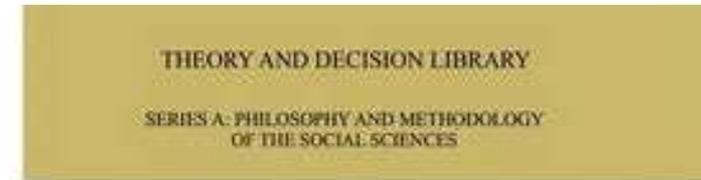
Demystifying the mathematics of uncertainty

As a critical tool for extended peer communities,
e.g. to deconstruct spoof evidence

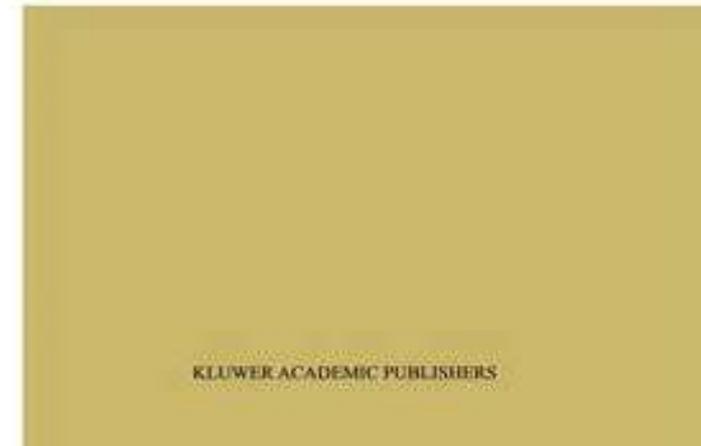
Opening up of frames

An old book from STS scholars Silvio Funtowicz and Jerome R. Ravetz's

(STS=studies of science and technology)



SILVIO O. FUNTOWICZ AND JEROME R. RAVETZ
UNCERTAINTY AND QUALITY
IN
SCIENCE FOR POLICY



Funtowicz, S. O. and Ravetz, J. R., 1990.
Uncertainty and quality in science for policy.
Dordrecht: Kluwer.



EPILOGUE

“...Numbers, however, are still esoteric knowledge, the property of a small set of initiates [...]

Only when there is effective quality control of science for policy, through the management of uncertainties, will we be able to cope intelligently with the crises we face.

The demystification of the mathematics of uncertainty is therefore a central part of the programme for the democratization of scientific expertise.”

Silvio O. Funtowicz & Jerome R. Ravetz, 1990.
Uncertainty and quality in science for policy. Kluwer: Dordrecht. p.
209



Quantitative story-
telling and
responsible
quantification

What is quantitative story telling?

- A truism: always listen more than one story
- An exhortation from philosophers
- A development from sensitivity analysis and sensitivity auditing
- A concept implicit in post-normal science's concept of "extended peer communities"

“There is only a perspective seeing, only a perspective “knowing”; and the more affects we allow to speak about one thing, the more eyes, different eyes, we can use to observe one thing, the more complete will our “concept” of this thing, our “objectivity”, be.”



Friedrich Nietzsche, Genealogy of Morals, Third Essay.

Stories, frames / framings, narratives

Some examples

Frames

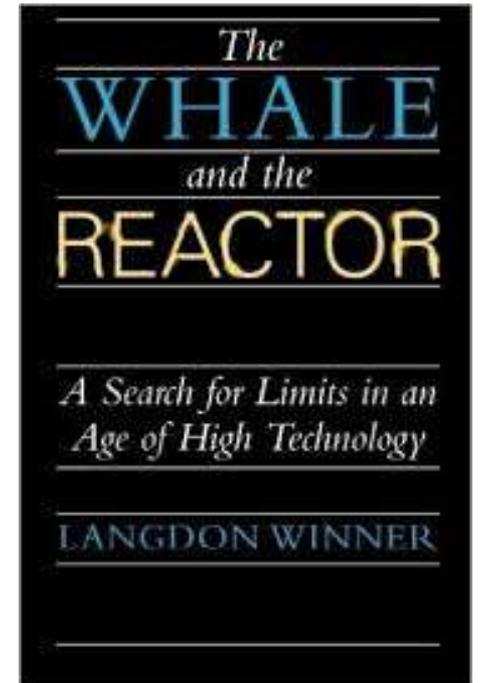
Most analyses offered as input to policy are framed as cost benefit analysis or risk analyses.

8

ON NOT HITTING
THE TAR-BABY



Langdon Winner



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

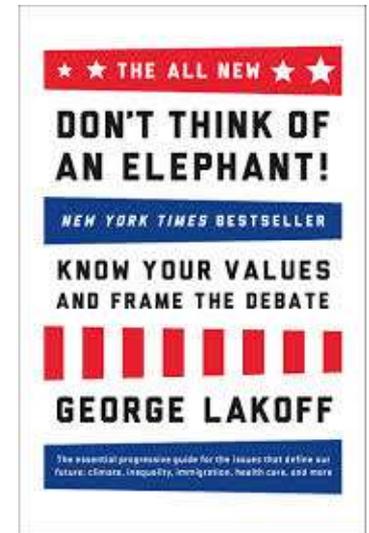
The expression ‘tax relief’ is apparently innocuous but it suggests that tax is a burden, as opposed to what pays for road, hospitals, education and other infrastructures of modern life (Lakoff, 2004).



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.



Frames

GMO treated as an issue of nutritional health safety by proponents and as an issue of power and control by opponents



The Economist, Vermont v science, The little state that could kneecap the biotech industry, May 10th 2014

Frames as hypocognition & Socially constructed ignorance

For Rayner (2012) “Sense-making is possible only through processes of exclusion. Storytelling is possible only because of the mass of detail that we leave out. Knowledge is possible only through the systematic ‘social construction of ignorance’ (Ravetz, 1986)”



Steve Rayner



Jerry Ravetz

Ravetz, J., R., 1987, Usable Knowledge, Usable Ignorance, Incomplete Science with Policy Implications, *Knowledge: Creation, Diffusion, Utilization*, 9(1), 87-116.

Rayner, S., 2012, Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses, *Economy and Society*, 41:1, 107-125.

Rayner's (2012) strategies societies may use to deal with “uncomfortable knowledge”.

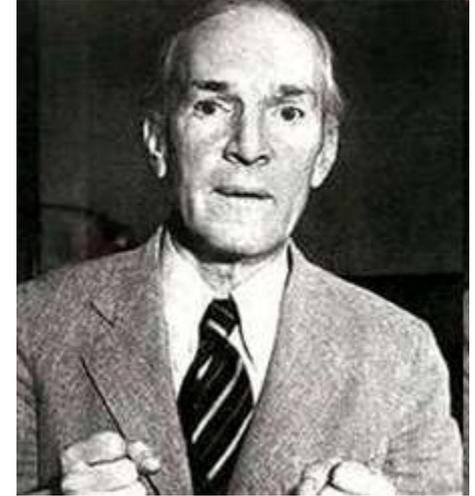
- Denial: “There isn’t a problem”
- Dismissal: “It’s a minor problem”
- Diversion: “Yes I am working on it” (In fact I am working on something that is only apparently related to the problem)
- Displacement: “Yes and the model we have developed tells us that real progress is being achieved” (The focus is now the model not the problem).

“Uncomfortable knowledge” can be used as a gauge of an institution’s health.

The larger the “uncomfortable knowledge” an institution needs to maintain, the closer it is to its ancient régime stage (Funtowicz and Ravetz, 1994).

Why frames ‘stick’

“It is difficult to get a man to understand something when his salary depends upon his not understanding it.”



Upton Sinclair

So what does quantitative story telling propose?

Instead of detailed quantification on a single[/few] frame[s] a rough quantitative appraise of a richer set of frames.



THE RIGHTFUL
PLACE OF SCIENCE:

**SCIENCE ON THE
VERGE**

CONTRIBUTORS

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Saltelli, A., Giampietro, M., Ravetz, J.R., 2016, Decalogue of the diligent quantifier. A Pledge.

Excerpts:

Don't quantify at gun point; My license to quantify is also a license not to quantify

Mind frames; mind motivations and power relations

Don't swipe assumptions under the carpet

Each measure need a stable external referent

...



How can sensitivity analysis play a role?

Mastering of the 'secrets'

First secret: The most important question is the question.

Corollary 1: Sensitivity analysis is not “run” on a model but on a model once applied to a question.

Corollary 2: The best setting for a sensitivity analysis is one when one wants to prove that a question cannot be answered given the model
[\sim null hypothesis in modelling]

It is better to be in a setting of falsification than in one of confirmation (Oreskes et al., 1994).

[Normally the opposite is the case]

Second secret: Sensitivity analysis should not be used to hide assumptions [it often is]



Third secret: If sensitivity analysis shows that a question cannot be answered by the model one should find another question/model which can be treated meaningfully.

[Often the love for the model prevails]

Badly kept secret:

There is always one more bug...

(Lubarsky's Law of Cybernetic Entomology)

And sensitivity analysis spots it!

Remember to justify why you are using one given methods among the available zillion on methods



= The application must drive the choice of the method

Don't ...

... run a sensitivity analysis where each factor has a 5% uncertainty



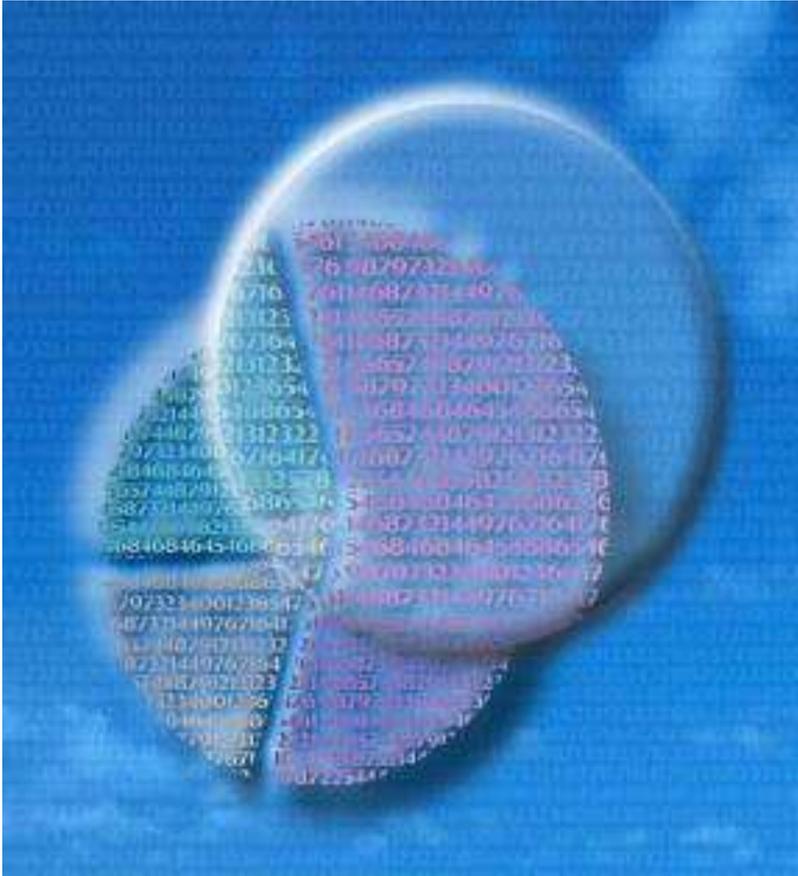


While sensitivity analysis enjoys universal recognition its use is scarce or deficient.

A general malaise? Loss of craft skills? A wider crisis of science's quality control apparatus?

Quantification and trust are linked. High responsibility of the quantifier.

Can sensitivity analysis and auditing help? To demystify spooof evidence, and fight hypocognition? A few SA-specific 'secrets' to help in this direction.



END

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