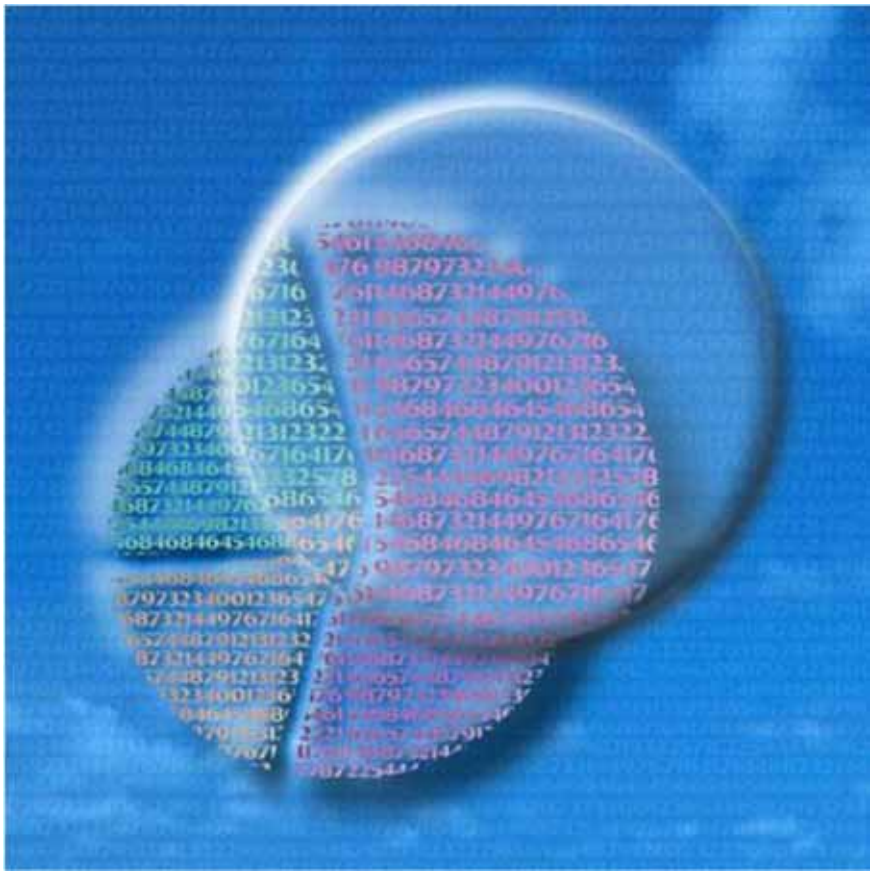


When all models are wrong

Andrea Saltelli, European Commission, Joint Research Centre

MPE 2013+ Workshop on Global Change
May 19 - 21, 2014
2060 Valley Life Sciences Building
University of California, Berkeley
DIMACS Centre for Discrete Mathematcs and Theoretical Computer Science
May 21 2014

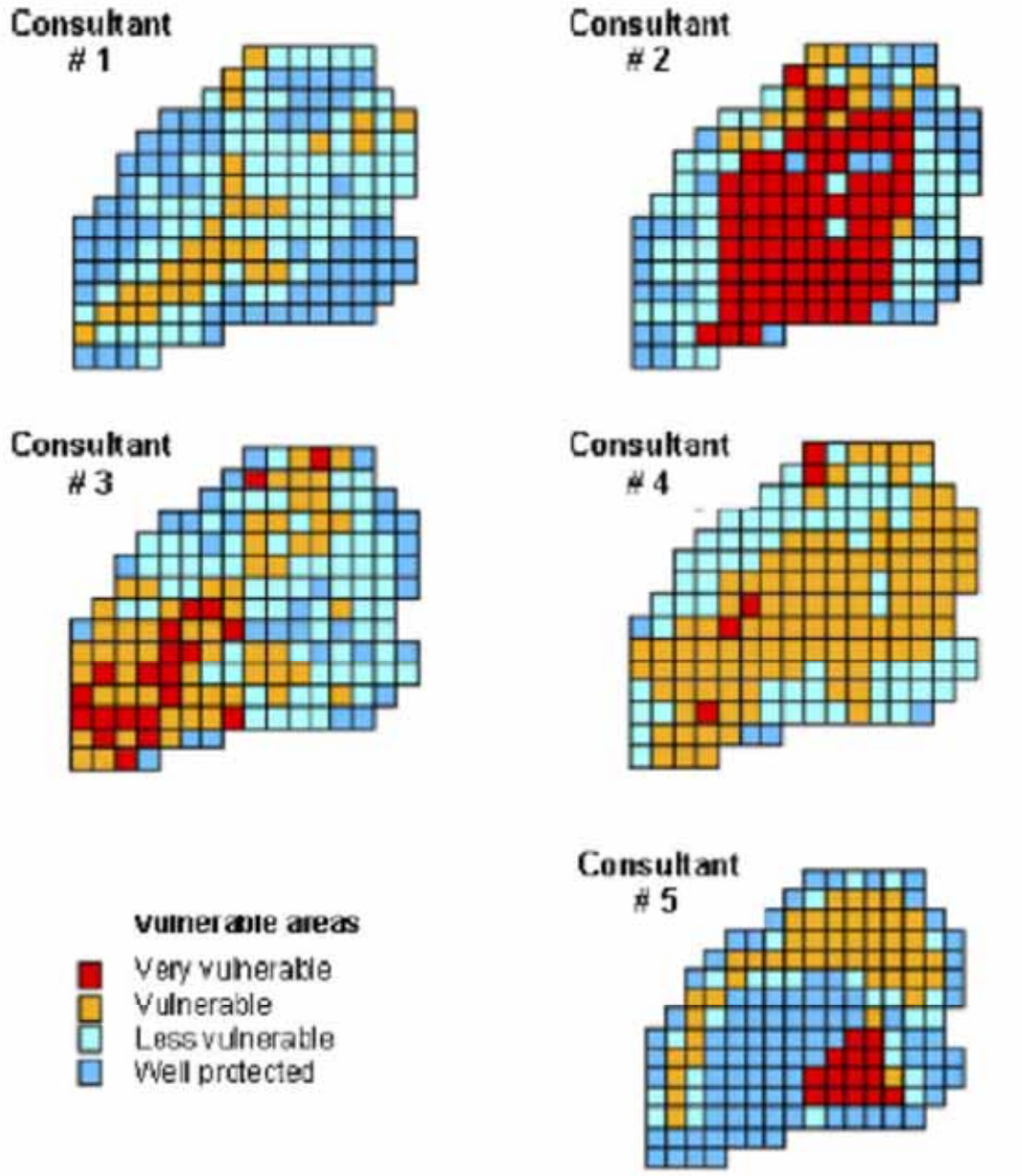
andrea.saltelli@jrc.ec.europa.eu

Copernicus Institute

Model structure uncertainty…

5 consultants, each using a different model were given the same question:
"which parts of this particular area are most vulnerable to pollution and need to be protected?"

(Refsgaard et al, 2006)



Courtesy of Dr. Jeroen P. van der Sluijs (1965)
Copernicus Institute of Sustainable Development, Utrecht University

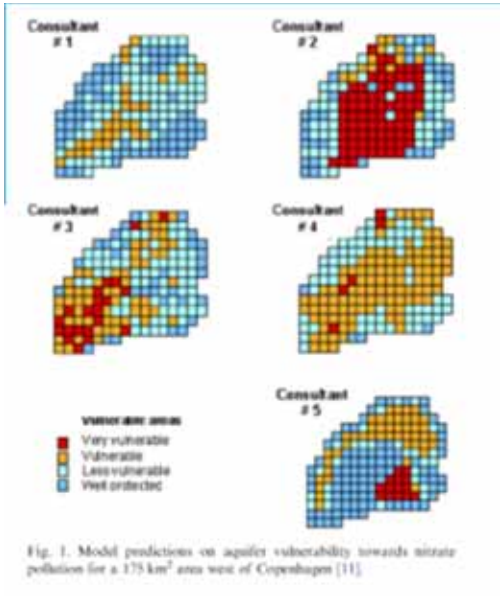


Fig. 1. Model predictions on aquifer vulnerability towards nitrate pollution for a 175 km² area west of Copenhagen [11].

How to act upon such uncertainty?

Bayesian approach: 5 priors. Average and update likelihood of each grid-cell being red with data (but oooops, there is no data and we need decisions now)

IPCC approach: Lock the 5 consultants up in a room and don't release them before they have **consensus**

Nihilist approach: Dump the science and decide on an other basis

Precautionary robustness approach: protect all grid-cells

Academic bureaucrat approach: Weigh by citation index (or H-index) of consultant.

Select the consultant that you **trust** most

Real life approach: Select the consultant that best fits your **policy agenda**

Post normal: explore the relevance of our ignorance: **working deliberatively within imperfections**

Courtesy of Dr. Jeroen P. van der Sluijs (1965)
Copernicus Institute of Sustainable Development, Utrecht University


NEWSFOCUS

Dueling Visions For a Hungry World

Sparks began to fly when scientists and activists against genetically modified crops came together to assess agricultural knowledge and the role of biotech in development

When economist Carl Pray heard about plans for the first international assessment of agricultural research, a gold standard sprang to mind: the Intergovernmental Panel on Climate Change (IPCC). But things didn't turn out the way he expected.

IPCC has been pivotal in proving that climate change is real and linking it to human activities. As an agricultural economist at Rutgers University who has worked in many poor countries, Pray is convinced that agricultural research—and genetic modification in

mentally, socially and economically sustainable development through the generation, access to, and use of agricultural knowledge, science and technology?" Critics say this broad mandate made conflict inevitable and stunted the assessment's analytical rigor.

On several key issues, consensus proved elusive. Industry scientists and some academics—mainly agricultural economists and plant biologists—believe the assessment was "hijacked" by participants who oppose genetically modified (GM) crops and other common

the outcome. They note that the voice and experience of small-scale farmers, particularly women, have finally been brought to the fore by the assessment. "It really deals with issues of power, influence, and benefits," says Marcia Ishii-Eiteman of the Pesticide Action Network North America in San Francisco, California. Toby Kiers, who studies sustainable agriculture at Vrije University in Amsterdam, the Netherlands, agrees. "For technology to be most effective, farmers must be at the center, influencing how it is developed, delivered, and

loaded from www.sciencemag.org on March

The IFPRI had raised about $460,000 for the modeling, which would have provided insights to help policymakers […]

[…] But Greenpeace […] objected that the models were not "transparent".

Source: Dueling visions for an hungry world, Erik Stokstad, 14 MARCH 2008, 319 SCIENCE


we reduce hunger and poverty, improve rural livelihoods, and facilitate equitable, environ-

community-based knowledge.

- Create space for diverse voices and include social scientists in policy.

suggested that the bank review the entire range of agricultural technologies and policies. Convinced that agricultural research should be considered in the context of the myriad factors

1474 14 MARCH 2008 VOL 319 SCIENCE www.sciencemag.org

Published by AAAS

We just can’t predict, says N. N. Taleb, and we are victims of the ludic fallacy, of delusion of uncertainty, and so on. Modelling is just another attempt to ‘Platonify’ reality…

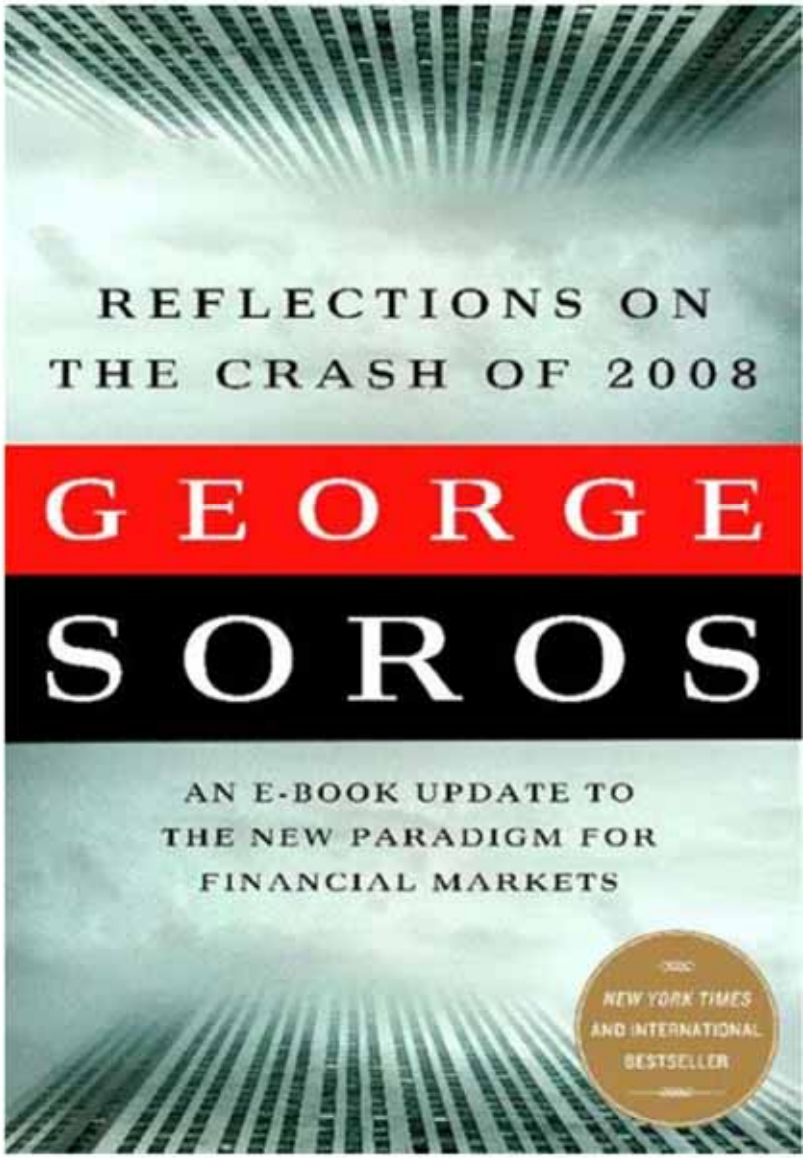
Written before the financial crisis

Nassim Nichola Taleb, The Black Swan, Penguin, London 2007

Postulate of 'radical fallibility':

"Whenever we acquire some useful knowledge, we tend to extend it to areas where it is no longer applicable"

(Taleb's -Platonification')



Models by their nature are like blinders. In leaving out certain things, they focus our attention on other things. They provide a frame through which we see the world.

Joseph E. Stiglitz, 2011, RETHINKING MACROECONOMICS: WHAT FAILED, AND HOW TO REPAIR IT, Journal of the European Economic Association August 2011 9(4):591–645

Caeteris are never paribus!

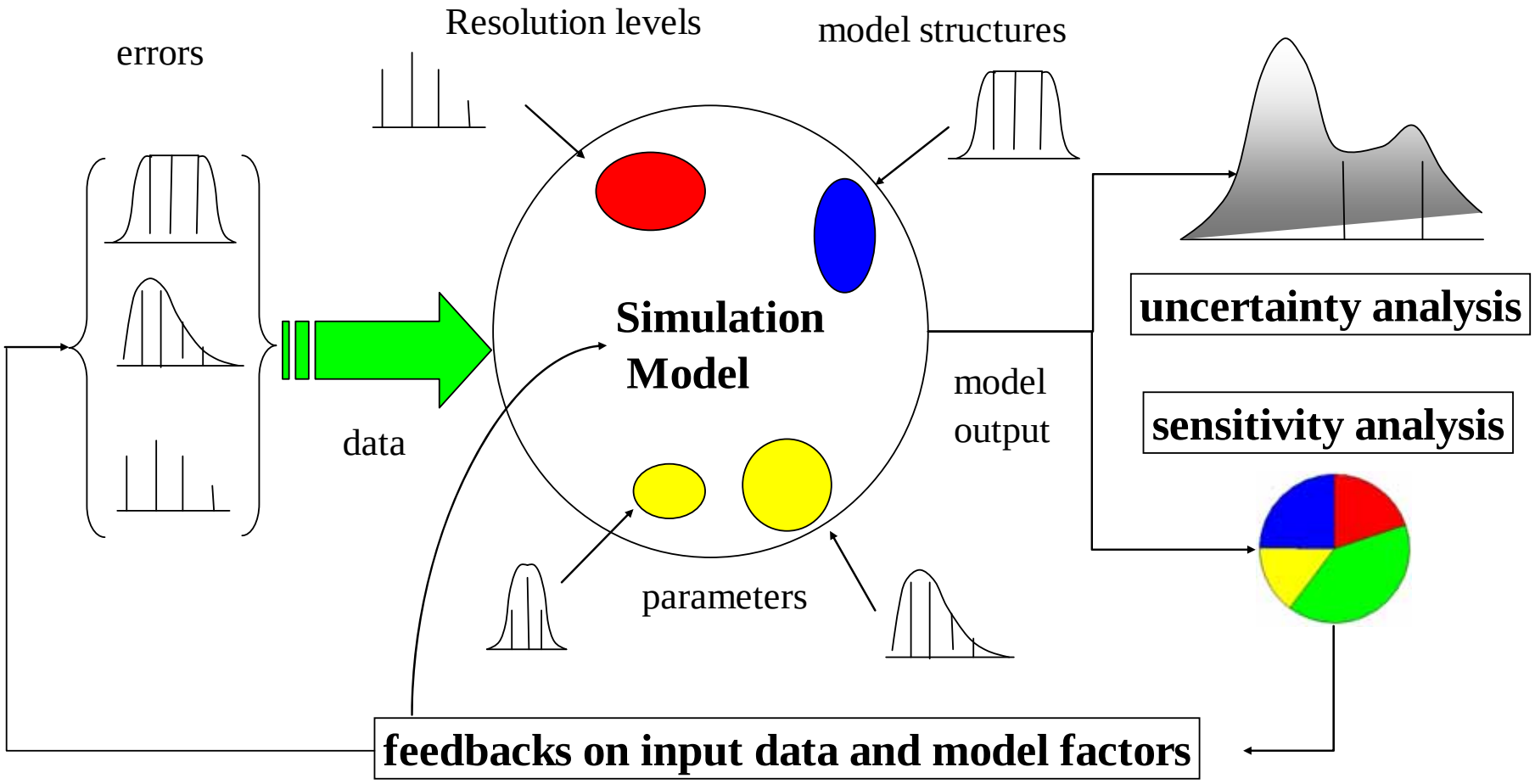
From sensitivity analysis to sensitivity auditing

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.

Available at http://issues.org/30-2/andrea/

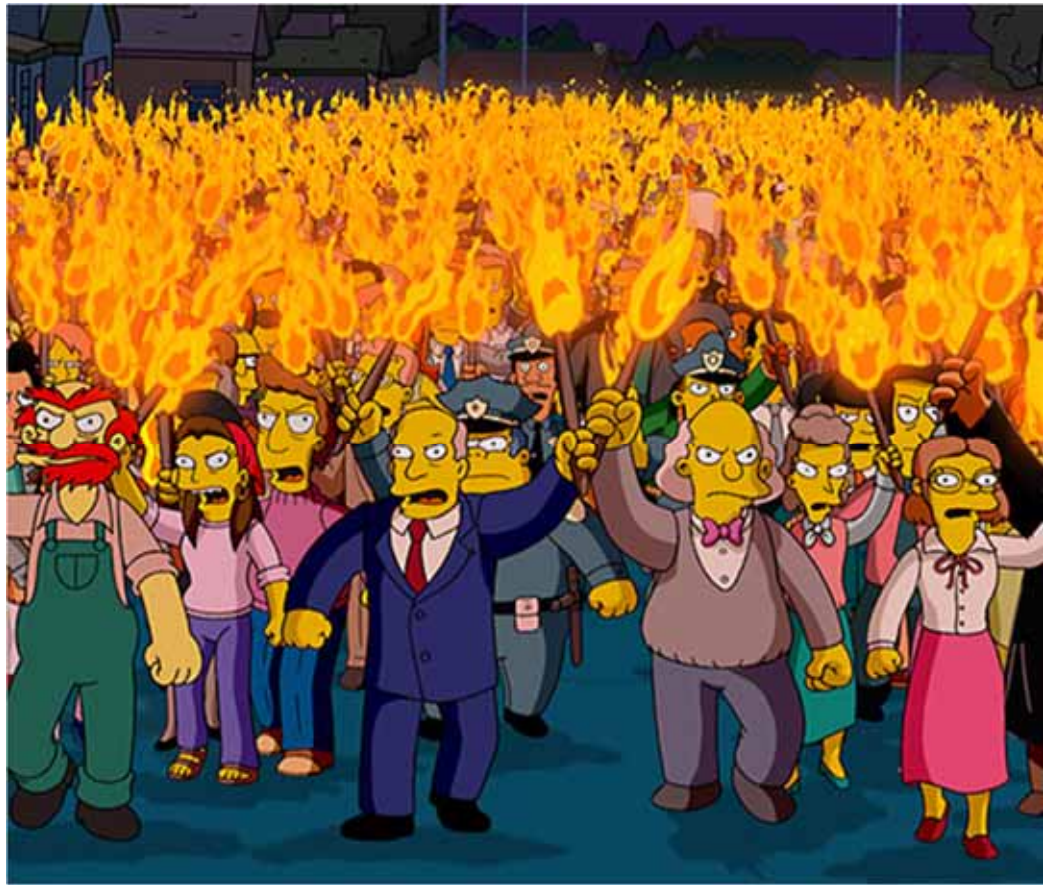
Sensitivity Analysis



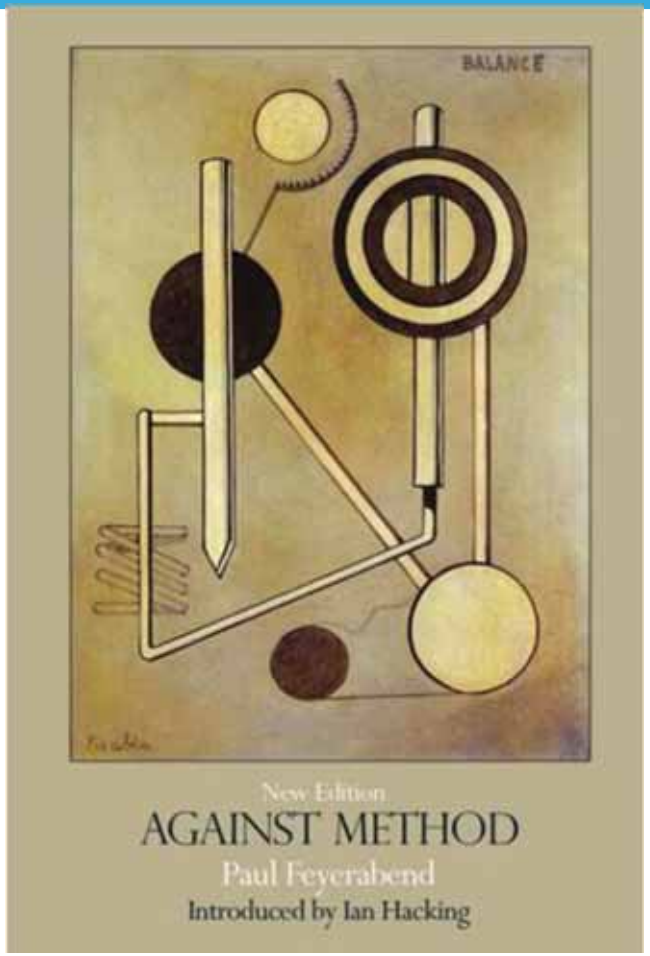
Sensitivity analysis, mandated by existing guidelines as a good practice to use in conjunction to mathematical modelling, is as such insufficient to ensure quality in the treatment of uncertainty of science for policy.

In an adversarial context not only the nature of the evidence, but also the degree of certainty and uncertainty associated to the evidence will be the subject of partisan interests

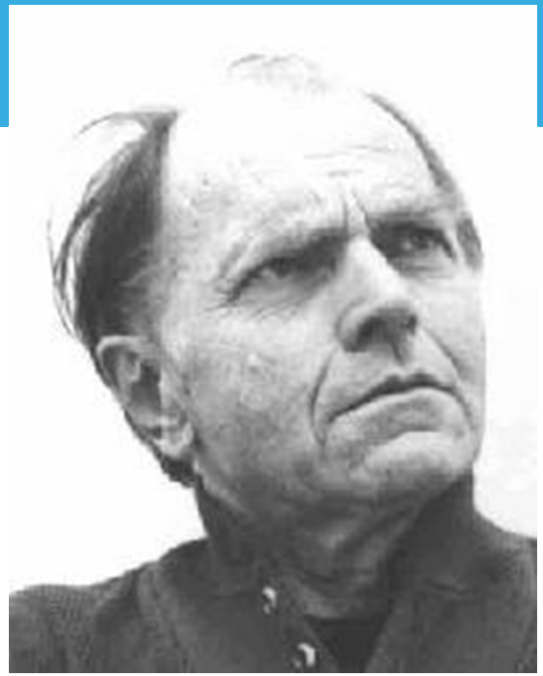
➔ Extended peer review



[…] in a democracy local populations not only will, but also should, use the sciences in ways most suitable to them. The objections that citizens do not have the expertise to judge scientific matters overlooks that important problems often lie across the boundaries of various sciences **so that scientists within these sciences don't have the needed expertise either.**



Moreover doubtful cases always produce experts from one side, experts for the other side, and experts in between. But the **competence of the general public could be vastly improved by an education that exposes expert fallibility** instead of acting as if it did not exist. (Paul Feyerabend, Against Method)



Paul Feyerabend

Transactions of the Institute of British Geographers
Royal Geographical Society with IBG

Doing flood risk science differently: an experiment in radical scientific method

S N Lane*, N Odoni*, C Landström**, S J Whatmore**, N Ward† and S Bradley‡

Trans Inst Br Geogr NS 36 15–36 2011
ISSN 0020-2754 © 2010 The Authors.

[…] knowledge regarding flooding was co-produced. This illustrates a way of working with experts, both certified (academic natural and social scientists) and noncertified (local people affected by flooding), […] We reveal a deep and distributed understanding of flood hydrology across all experts, certified and uncertified, …

[…] the purpose of our experiment became as much about creating a new public capable of making a political intervention in a situation of impasse, as it was about producing the solution itself.

The practice of knowledge generation, the science undertaken, worked with the hybridisation of science and politics rather than trying to extract science from it.

From sensitivity analysis to sensitivity auditing; Seven rules

European Commission

1. Check against rhetoric use of mathematical modeling [is the m
obfuscate?]:

2. Adopt an 'assumption hunting' attitude [what
possibly normative assumptions underlying the

3. Detect Garbage In Garbage
d in order to achieve
a desired inference at a desired

4. Find sensiti

5. A
ake sense of, and possibly replicate, the results
of

6.
ian 'Do the sums right'; is the viewpoint of a relevant
stakeh

7. Fo
he key question answered by the model, exploring holistically the entire space of
the assump
do perfunctory analyses changing one factor at a time].

Joint Research Centre

RULE ONE: Check against rhetorical use of mathematical modelling

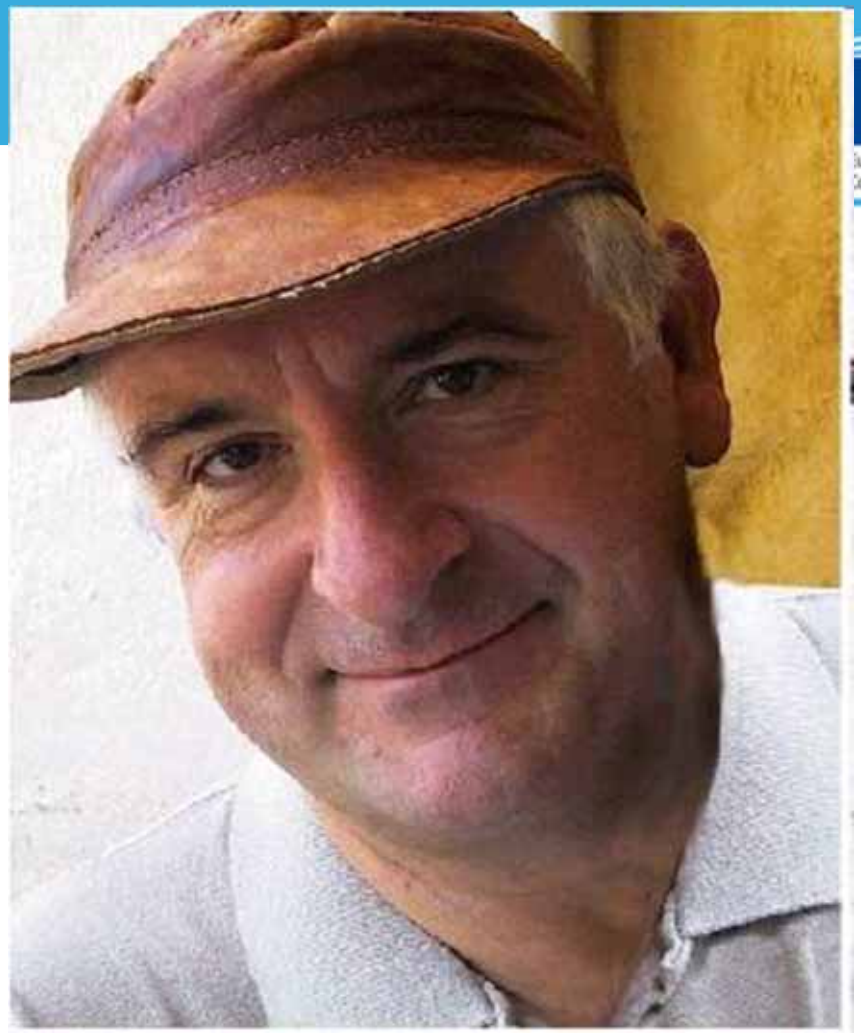
The instrumental use of mathematical modelling to advance one's agenda can be termed rhetorical, or strategic, like the use of Latin by the elites and the clergy in the classic age.

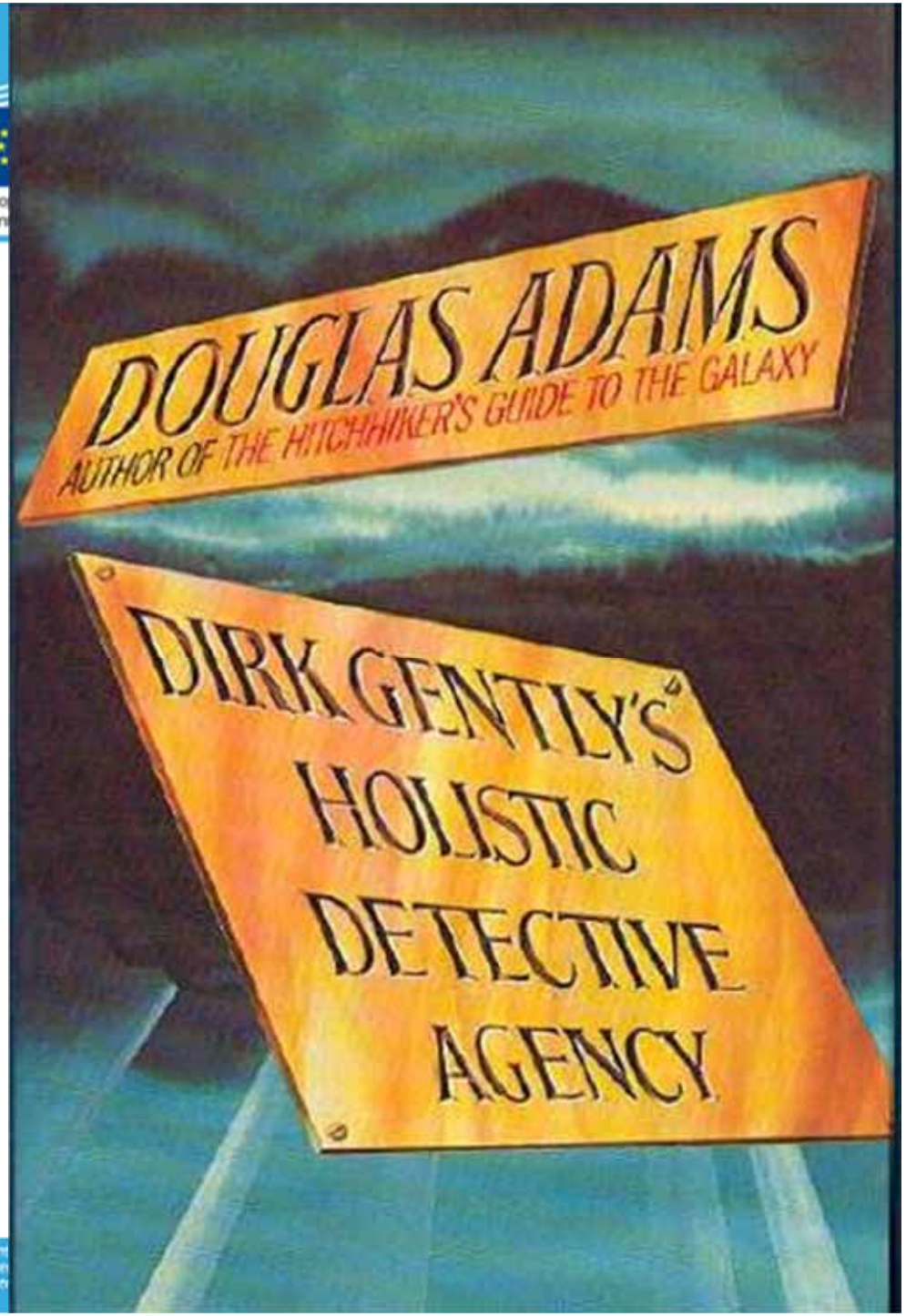
RULE ONE: Check against rhetorical use of mathematical modelling

George M. Hornberger, Professor at University of Viginia

<<[…] most simulation models will be complex, with many parameters, state-variables and non linear relations. Under the best circumstances, such models have many degrees of freedom and, with judicious fiddling, can be made to produce virtually any desired behaviour, often with both plausible structure and parameter values.>>

HORNBERGER and Spear (1981).





Douglas Adam
Pocket Books 1987, p.69

RULE ONE: Check against rhetorical use of mathematical modelling

"Well, Gordon's great insight was to design a program which allowed you to specify in advance what decision you wished it to reach, and only then to give it all the facts. The program's task, […], was to construct a plausible series of logical-sounding steps to connect the premises with the conclusion."

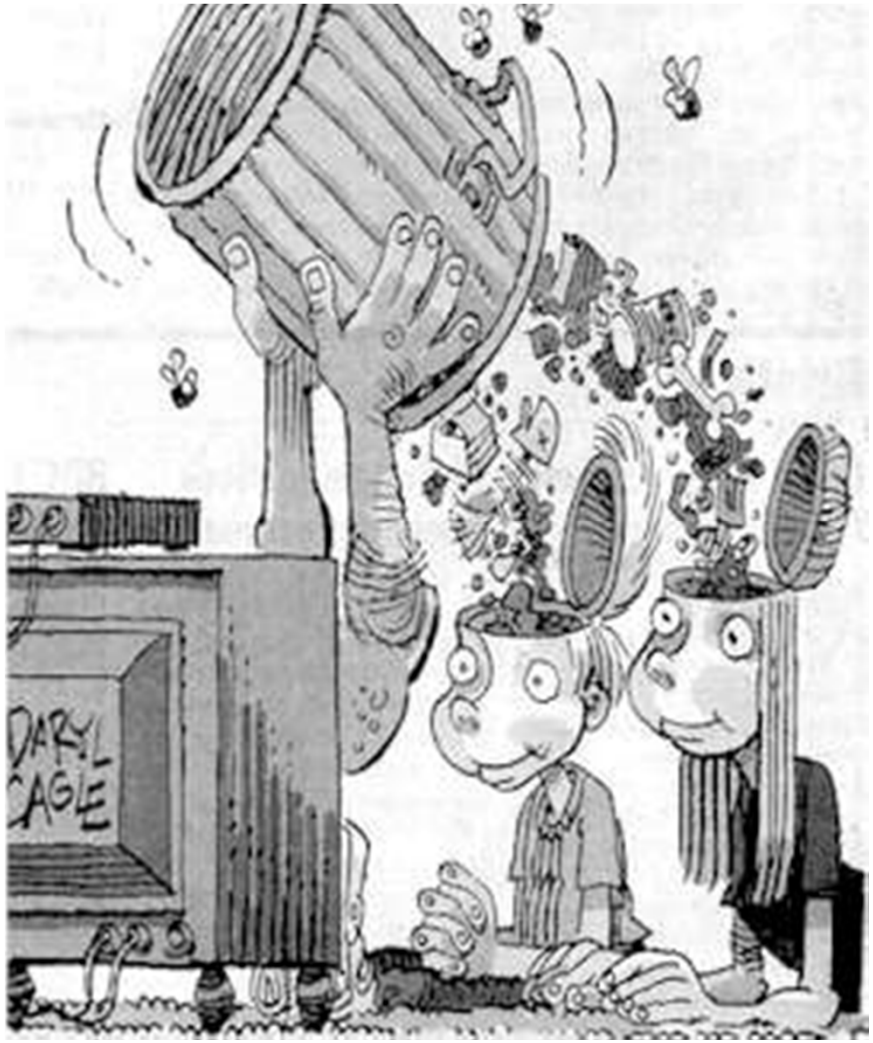
RULE TWO: Adopt an ‘assumption hunting’ attitude;

What was ‘assumed out’? What are the tacit, pre-analytic, possibly normative assumptions underlying the analysis?

E.g. in ‘Bogus Quantification: Uses and Abuses of Models’ John Kay uncovers that the UK transport WebTAG model (the standard for transport policy simulation) needs as input ‘Annual Percentage Change in Car Occupancy up to 2036.’

John Kay, London School Economics, Columnist Financial Times

RULE THREE: detect GIGO (Garbage In, Garbage Out) Science or pseudo-science



RULE THREE: detect GIGO (Garbage In, Garbage Out) Science or pseudo-science

"where uncertainties in inputs must be suppressed lest outputs become indeterminate"

From: Uncertainty and Quality in Science for Policy
by Silvio Funtowicz and Jerry Ravetz, Springer 1990.

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

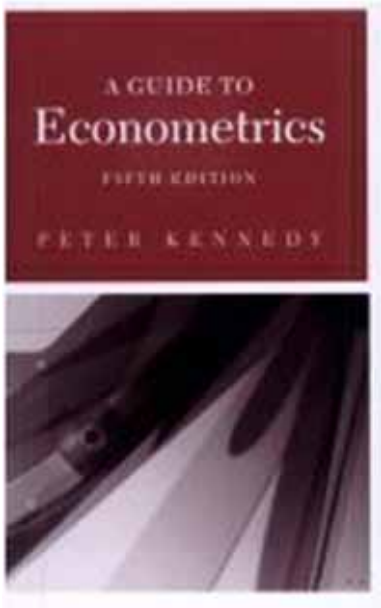
<<I have proposed a form of organised sensitivity analysis that I call “global sensitivity analysis” in which a neighborhood of alternative assumptions is selected and the corresponding interval of inferences is identified.
Conclusions are judged to be sturdy only if the neighborhood of assumptions is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

RULE FOUR: find sensitivities before sensitivities find you;

RULE FOUR : find sensitivities before sensitivities find you;

Peter Kennedy, A Guide to Econometrics. Anticipating criticism by applying sensitivity analysis. This is one of the ten commandments of applied econometrics according to Peter Kennedy:

<<Thou shall confess in the presence of sensitivity.
Corollary: Thou shall anticipate criticism >>



RULE FIVE: aim for transparency

European Commission

Doubts raised over Europe's green energy plan

'Host of questions' from advisers

Economic model lacks transparency

By Pilita Clark in London

The credibility of a European energy review has been cast into doubt by specialist advisers who say plans to cut carbon emissions up to 2050 are based on an economic model owned by a single Greek university that cannot be independently scrutinised.

The energy experts have "raised a host of questions" on how the European Commission's use of a non-transparent model could affect the review, according to a leaked report by advisers chosen by Brussels to comment on the "Energy Roadmap 2050" proposals.

The economic model, known as Primes, is owned by the National Technical University of Athens and is designed to show how the use of different mixes of energy sources affect the wider economy.

The European Commission has used it for many years to help guide the bloc's energy policies. But industry critics complain that its assumptions are impossible to question because the model is privately owned. One think group, Business Europe, has called for the Commission to use other, more transparent models.

The forthcoming reform of the energy road map, which will review the effect of choosing gas, more wind and less nuclear power to meet Europe's green targets, has heightened concerns about the model's transparency, the expert advisory group report shows. One of the group's three meetings was "devoted largely" to how the Commission was using the Primes model to produce different energy mix scenarios for the road map.

"There was considerable debate about the role of the oil fuel price assumptions in the Primes model," said the report by the group, which is chaired by Dieter Helm, an Oxford university economics professor, and includes bodies such as the International Energy Agency.

There were also questions on "the costs of different technologies" and "the assumptions of public discount rate by companies but not by individuals".

The group's key concern was "about the transparency of the Primes work, and in particular the properties rights in the algorithms and detailed internal workings of the model", says the report, which is marked "final draft".

"The model remains the private property of the National Technical University of Athens," it says.

"The consequence is that independent parties cannot replicate the results. This is a substantial matter for the Commission, but members of the group pointed out that it does have obvious consequences for the credibility of the road map."

The advisory group recommends that the Primes model be made publicly available "so that its results can be replicated by interested parties".

Pantelis Capros, an economist from the National Technical University of Athens who built the Primes model, told the Financial Times he agreed that transparency was important and would try and find a way of the model's workings were made public, "but not the code itself – not the software".

A spokeswoman for the energy commissioner, Günther Oettinger, said she could not comment on an unpublished document. The final version of the advisory group's report would be released with the energy road map next month.

Paul Caprez has been an energy consultant for many years and has held positions on bodies ranging from Greece's energy regulator to the country's Public Power Corporation.

A mining plant in Germany: the credibility of plans to cut EU emissions has been called into question by experts

'Independent parties cannot replicate the results because the model is private property'

Joint Research Centre

RULE FIVE: aim for transparency

"Experts have "raised a host of questions" about how the European Commission's use of a non-transparent model could affect the energy review, [in] "Energy Roadmap to 2050"

Financial Times
November 6, 2011

RULE FIVE: aim for transparency

"The credibility of a European energy review has been cast into doubt by experts who point out that long-term plans to cut carbon emissions are **based on an economic model owned by a single Greek university that cannot be independently scrutinised**."

RULE FIVE: aim for transparency

House Republicans Aim To Limit Power Of Environmental Protection Agency

This is 2014

The Huffington Post | by Robin Wilkey (/robin-wilkey)

Posted: 02/07/2014 6:18 pm EST | Updated: 02/08/2014 10:59 am EST

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

I

113TH CONGRESS
2D SESSION

H. R. 4012

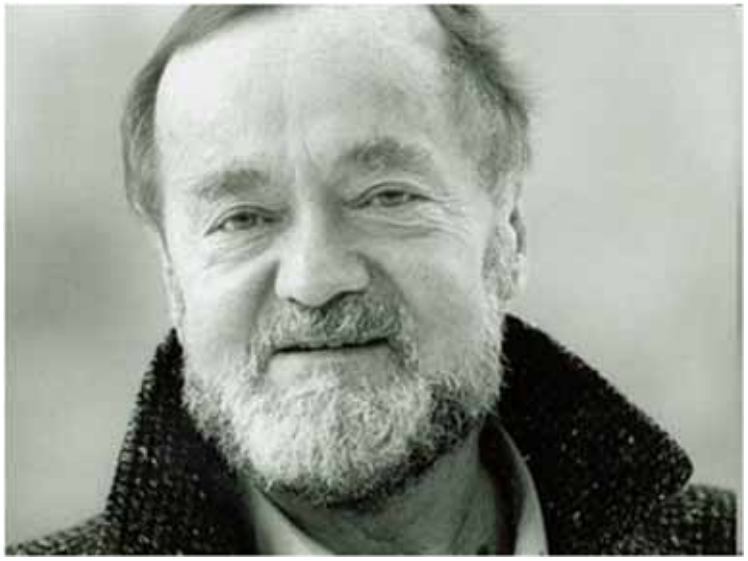
To prohibit the Environmental Protection Agency from proposing, finalizing, or disseminating regulations or assessments based upon science that is not transparent or reproducible.

http://beta.congress.gov/bill/113th-congress/house-bill/4012
Accessed May 2014

RULE FIVE: aim for transparency

The bill, dubbed the Secret Science Reform Act would force the EPA to publicly release its research on a topic before issuing a policy recommendation, and require that the research be "reproducible." Supporters claim the bill will increase transparency in public policy, while opponents have accused the bill's authors of trying to “keep the EPA from doing its job.”

RULE SIX: Do the right sums



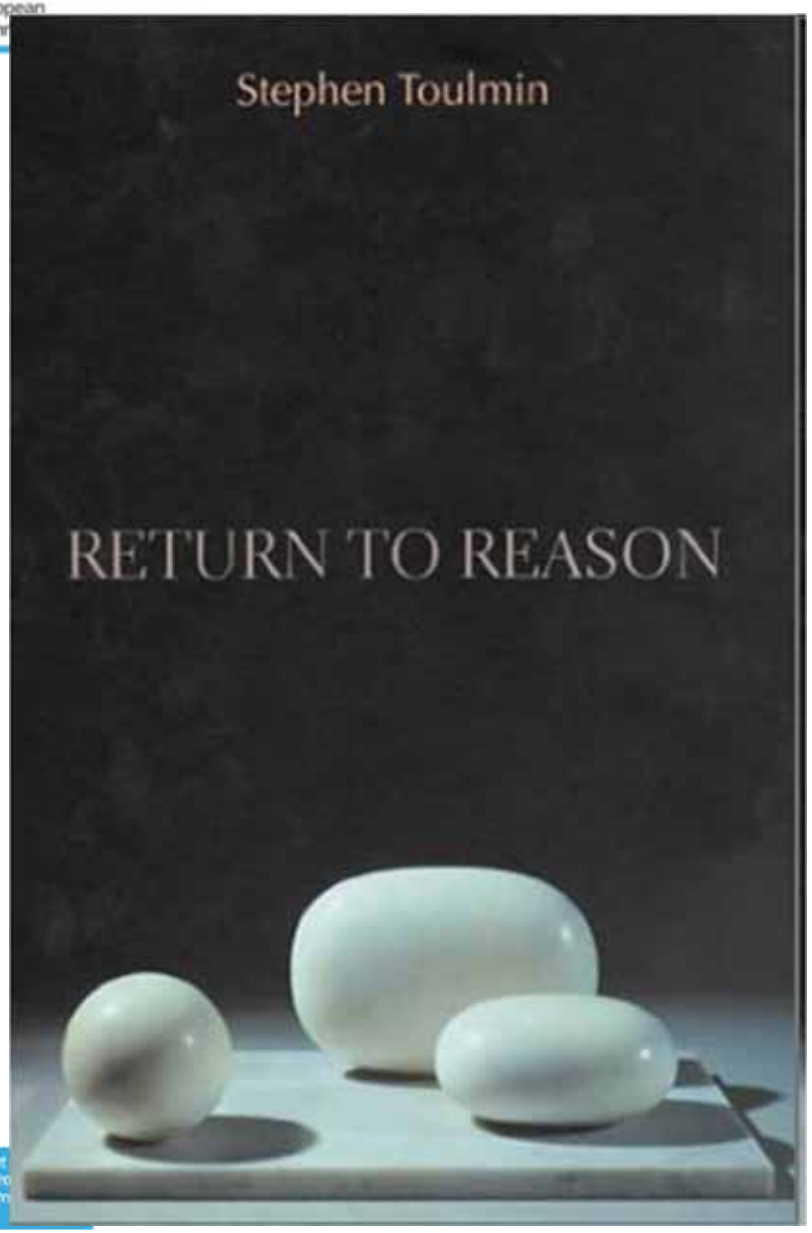
Do the sum right

Versus

Do the right sums

(*Stephen Toulmin*)

A plea for reasonableness versus rationality



RULE SIX: Do the right sums

Peter Kennedy's commandment of applied econometrics: 'Thou shall answer the right question', Kennedy 2007

RULE SIX: Do the right sums

Final Report of the PABE research project funded by the Commission of European Communities, Contract number: FAIR CT98-3844 (DG12 - SSMI), December 2001

- Why do we need GMOs? What are the benefits?
- Who will benefit from their use?
- Who decided that they should be developed and how?
- Why were we not better informed about their use in our food, *before* their arrival on the market?
- Why are we not given an effective choice about whether or not to buy and consume these products?
- Do regulatory authorities have sufficient powers and resources to effectively counter-balance large companies who wish to develop these products?

…

RULE SEVEN: Explore diligently the space of the assumptions

Environmental Modelling & Software 25 (2010) 1508–1517

Contents lists available at ScienceDirect

Environmental Modelling & Software

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

How to avoid a perfunctory sensitivity analysis

Andrea Saltelli*, Paola Annoni

Joint Research Center, Institute for the Protection and Security of the Citizen, via E.Fermi, 2749, Ispra VA 21027, Italy

RULE SEVEN: Explore diligently the space of the assumptions

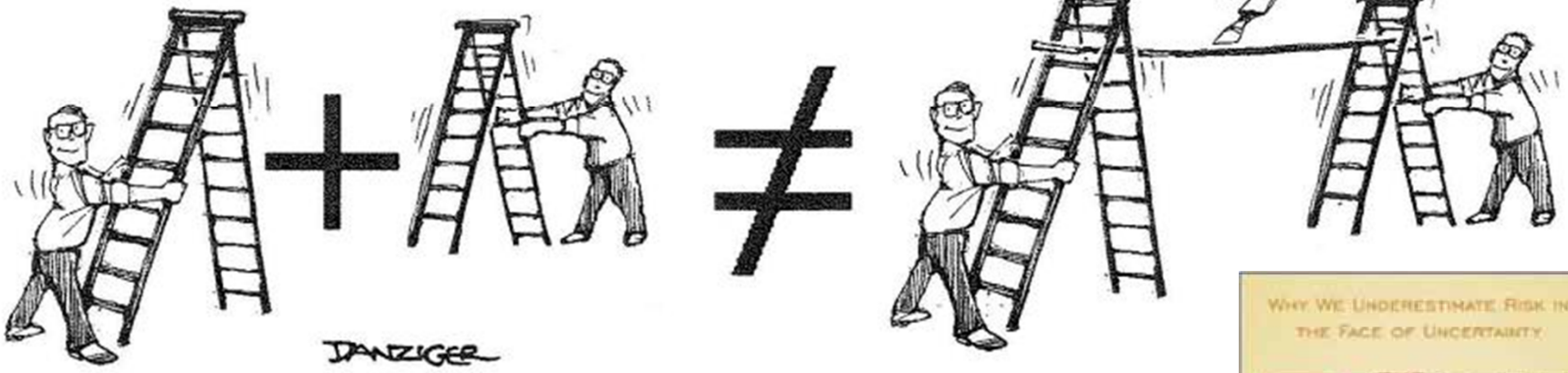
The most popular SA practice seen in the literature is that of 'one-factor-at-a-time' (OAT). This consists of analyzing the effect of varying one model input factor at a time while keeping all other fixed.

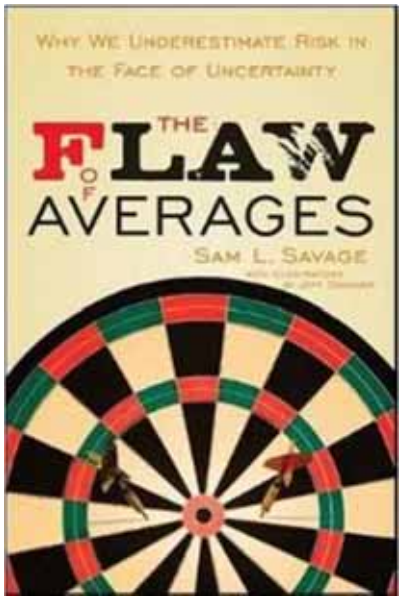
While the shortcomings of OAT are known from the statistical literature, its widespread use among modelers raises concern on the quality of the associated sensitivity analyses

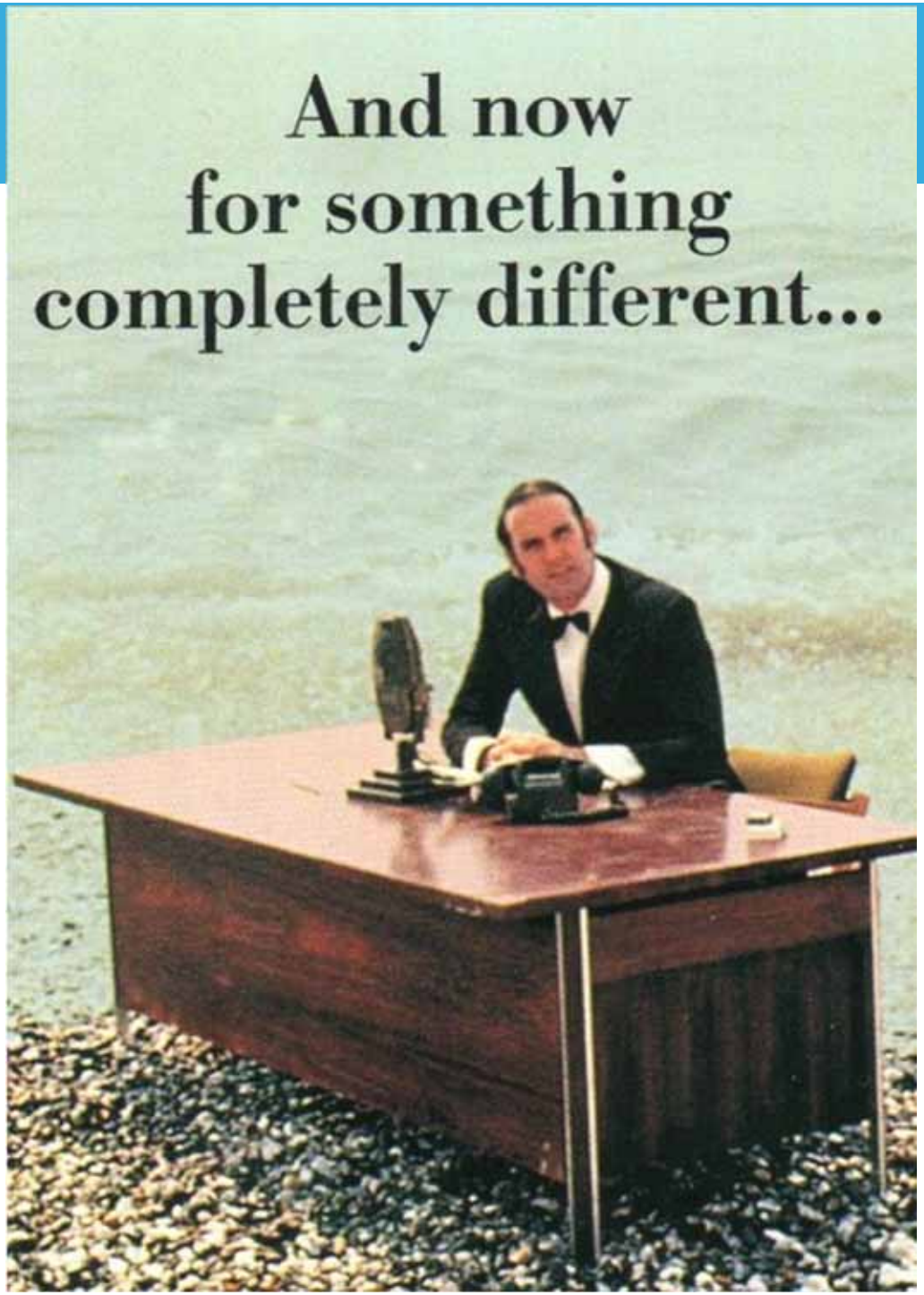
RULE SEVEN: Explore diligently the space of the assumptions

How coupled ladders are shaken in most of available literature

How to shake coupled ladders






And now
for something
completely different...

The Washington Post

‘Based on mountains of data from 39 models and accurate within five years in either direction for any of the locations they studied.’

Washington Post, October 9th 2013

D.C. climate will shift in 2047, researchers say; tropics will feel unprecedented change first

ARTICLE

doi:10.1038/nature12540

The projected timing of climate departure from recent variability

Camilo Mora[1], Abby G. Frazier[1], Ryan J. Longman[1], Rachel S. Dacks[2], Maya M. Walton[2,3], Eric J. Tong[3,4], Joseph J. Sanchez[1], Lauren R. Kaiser[1], Yuko O. Stender[1,3], James M. Anderson[2,3], Christine M. Ambrosino[2,3], Iria Fernandez-Silva[3,5], Louise M. Giuseffi[1] & Thomas W. Giambelluca[1]

Ecological and societal disruptions by modern climate change are critically determined by the time frame over which climates shift beyond historical analogues. Here we present a new index of the year when the projected mean climate of a given location moves to a state continuously outside the bounds of historical variability under alternative greenhouse gas emissions scenarios. Using 1860 to 2005 as the historical period, this index has a global mean of 2069 (±18 years s.d.) for near-surface air temperature under an emissions stabilization scenario and 2047 (±14 years s.d.) under a 'business-as-usual' scenario. Unprecedented climates will occur earliest in the tropics and among low-income countries, highlighting the vulnerability of global biodiversity and the limited governmental capacity to respond to the impacts of climate change. Our findings shed light on the urgency of mitigating greenhouse gas emissions if climates potentially harmful to biodiversity and society are to be prevented.

+/- 14 degrees and not five,

Joint Research Centre

Richard Tol

Bogus prophecies of doom will not fix the climate

Climate change demands action but not just on emissions, writes Richard Tol
Financial Times, March 31, 2014

http://en.wikipedia.org/wiki/Richard_Tol

Richard Tol

‘According to Monday’s report by the Intergovernmental Panel on Climate Change, a further warming of 2C could cause losses equivalent to 0.2-2 per cent of world gross domestic product.

On current trends, that level of warming would happen some time in the second half of the 21st century.

In other words, half a century of climate change is about as bad as losing one year of economic growth.’

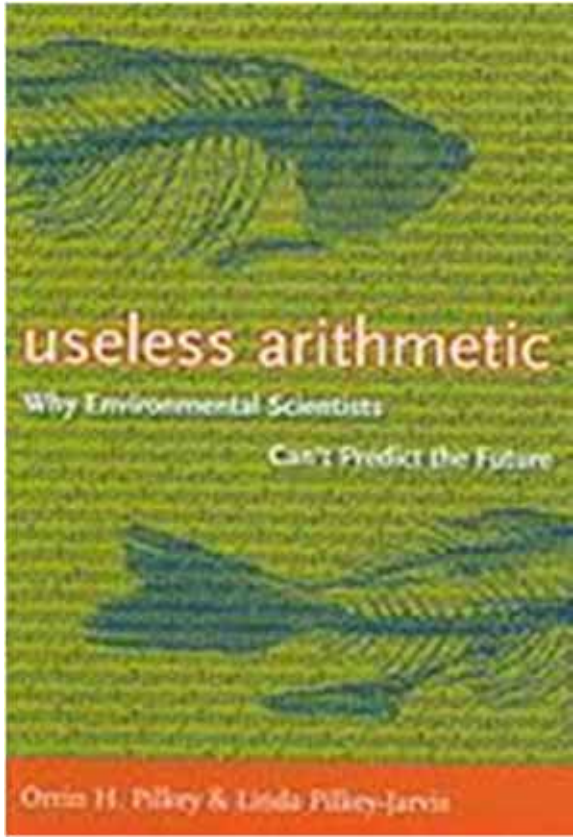
Richard Tol

Since the start of the crisis in the eurozone, the income of the average Greek has fallen more than 20 per cent. Climate change is not, then, the biggest problem facing humankind. It is not even its biggest environmental problem.

Richard Tol

The World Health Organisation estimates that about 7m people are now dying each year as a result of air pollution. Even on the most pessimistic estimates, climate change is not expected to cause loss of life on that scale for another 100 years.

Orrin H. Pilkey and Linda Pilkey-Jarvis



Useless Arithmetic: Why Environmental Scientists Can't Predict the Future
by Orrin H. Pilkey and Linda Pilkey-Jarvis

'Quantitative mathematical models used by policy makers and government administrators to form environmental policies are seriously flawed'

Orrin H. Pilkey and Linda Pilkey-Jarvis

Pilkey and Pilkey-Jarvis (2007:86) argue that the climate-sceptics' work would be harder if:

'[…] the global change modeling community would firmly and publicly recognize that its efforts to truly quantify the future are an academic exercise and that existing field data on atmospheric temperatures, melting glaciers, […] and other evidence should be relied on to a much greater degree to convince politicians that we have a problem.'

Orrin H. Pilkey and Linda Pilkey-Jarvis

‘Let the models point to a trend and answer ‘what-if’ questions. **A serious societal debate about ‘solutions’ can never occur as long as modellers hold out the probability, just around the corner, of accurate projections of future climates and seal-level position.’**

Nature, April 2014

NATURE | COMMENT

Global warming: Improve economic models of climate change

Nature, April 2014

NATURE | COMMENT

Global warming: Improve economic models of climate change

Richard L. Revesz, Peter H. Howard, Kenneth Arrow, Lawrence H. Goulder, Robert E. Kopp, Michael A. Livermore, Michael Oppenheimer & Thomas Sterner

04 April 2014

‘Costs of carbon emissions are being underestimated, but current estimates are still valuable for setting mitigation policy, say Richard L. Revesz and colleagues’

Nature, April 2014

NATURE | COMMENT

Global warming: Improve economic models of climate change

‘On 31 March, the Intergovernmental Panel on Climate Change (IPCC) released its latest report on the impacts of climate change on humans and ecosystems (see go.nature.com/ad5v1b). **These are real risks that need to be accounted for in planning for adaptation and mitigation. Pricing the risks with integrated models of physics and economics lets their costs be compared to those of limiting climate change or investing in greater resilience.**’

Nature, April 2014

NATURE | COMMENT

Global warming: Improve economic models of climate change

‘Yet the social-cost benchmark is under fire. Industry groups, politicians — including leaders of the energy and commerce committee of the US House of Representatives — and some academics say that uncertainties render the estimate useless. **As legal, climate-science and economics experts, we believe that the current estimate for the social cost of carbon is useful for policy-making, notwithstanding the significant uncertainties.**’

Chapter 2
Modelling the Climate System: An Overview

Gabriele Gramelsberger and Johann Feichter

G. Gramelsberger and J. Feichter (eds.), *Climate Change and Policy*,
DOI 10.1007/978-3-642-17700-2_2,

Gramelsberger and Feichter

In a way climate change science and policy seems to be trapped between Scylla and Charybdis. Avoiding climate change entails approaching the danger of economic calamity, and vice versa. This is not entirely true, as recent studies have shown that the 2^0C target might cost on the order of 1% of Gross Domestic Product […].

Gramelsberger and Feichter

However, if mankind is unable to decide how to frame an appropriate response to climate change, **nature will decide for both—environmental and economic calamities—as the economy is inextricably interconnected with the climate.**

A sensitivity auditing

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.

A sensitivity auditing

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).

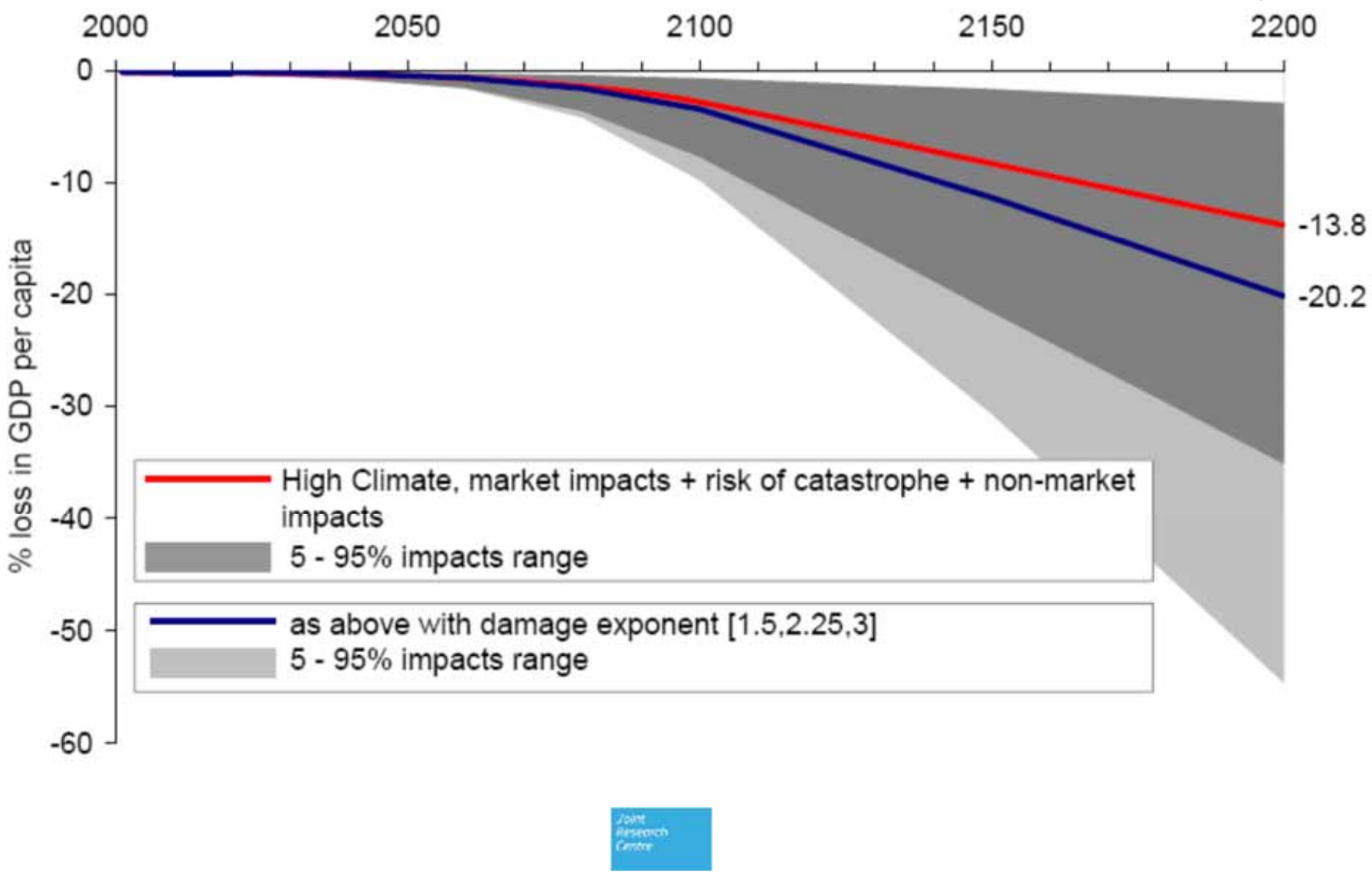
A sensitivity auditing

Stern's Review – Technical Annex to postscript (a sensitivity analysis of a cost benefit analysis)

The Stern - Nordhaus exchange on *SCIENCE*

Nordhaus → falsifies Stern based on 'wrong' range of discount rate (~ you GIGOing)
Stern → 'My analysis shows robustness'

My problems with it:



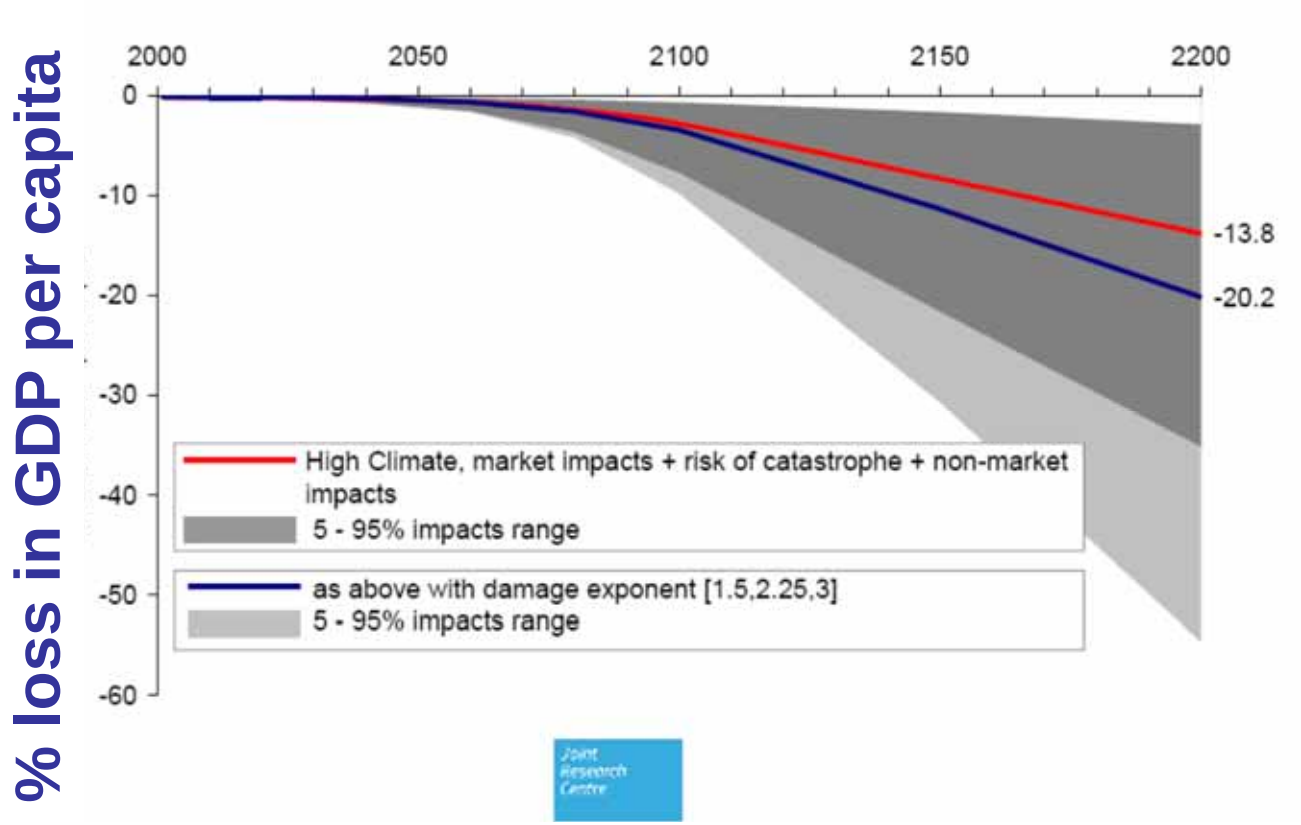
A sensitivity auditing

… but foremost Stern says:

changing assumptions → important effect

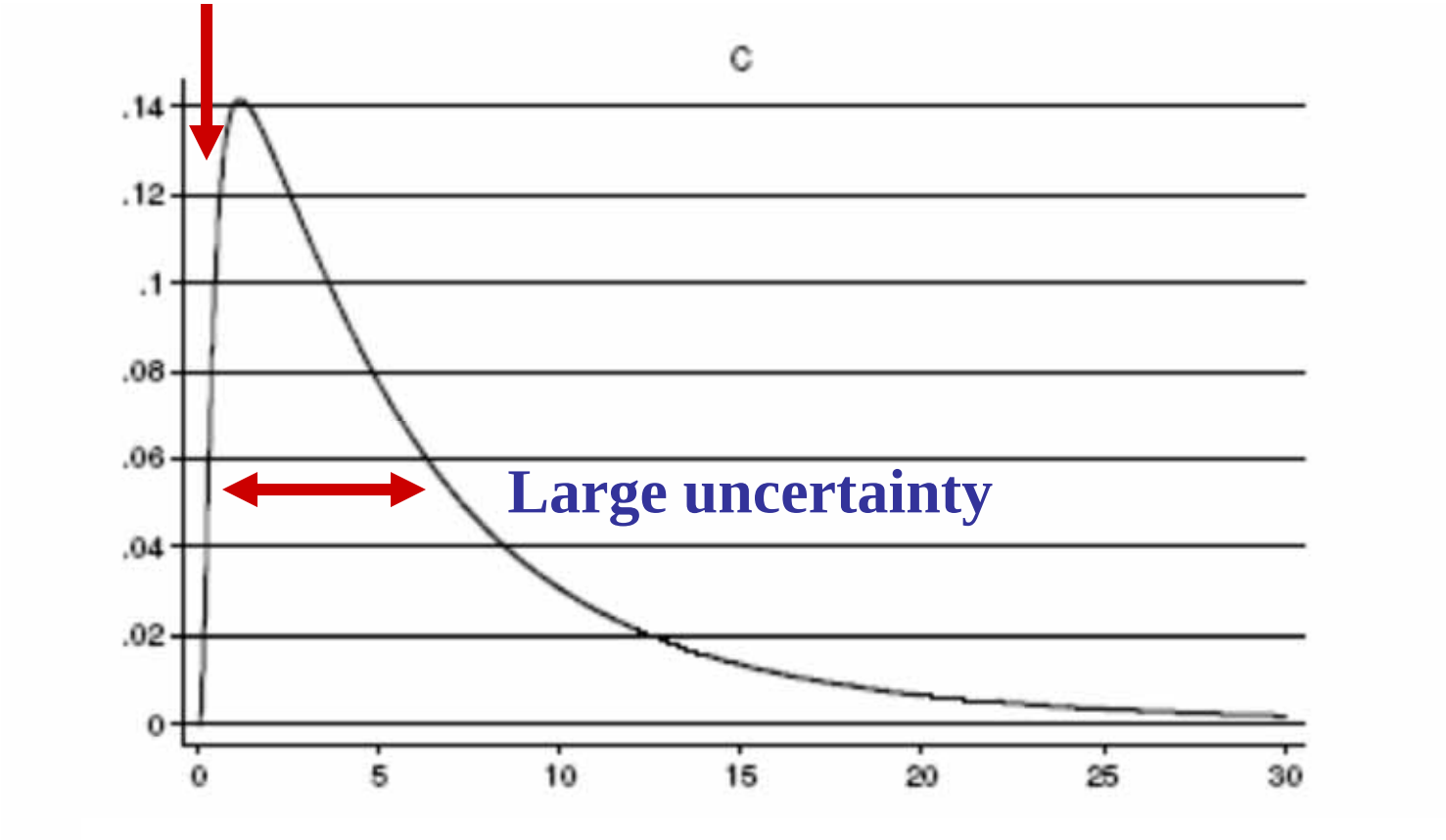
when instead he should admit that:

changing assumptions → all changes a lot



How was it done? A reverse engineering of the analysis

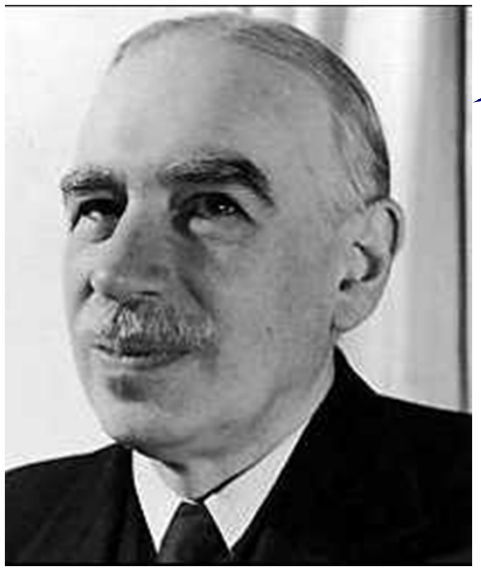
Missing points



% loss in GDP per capita

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

… precisely wrong



Comments on the Stern Review's Economics of Climate Change*

Sir Partha Dasgupta, FBA FRS
Frank Ramsey Professor of Economics
University of Cambridge

November 11, 2006
(Revised: December 12, 2006)

About discount factors. A critique of the way delta (intergenerational) and eta (aversion to inequality) are set in the review;

“[…] to suppose that eta is 1 is also to suppose that starvation isn't all that painful!”

Comments on the Stern Review's Economics of Climate Change*

Sir Partha Dasgupta, FBA FRS
Frank Ramsey Professor of Economics
University of Cambridge

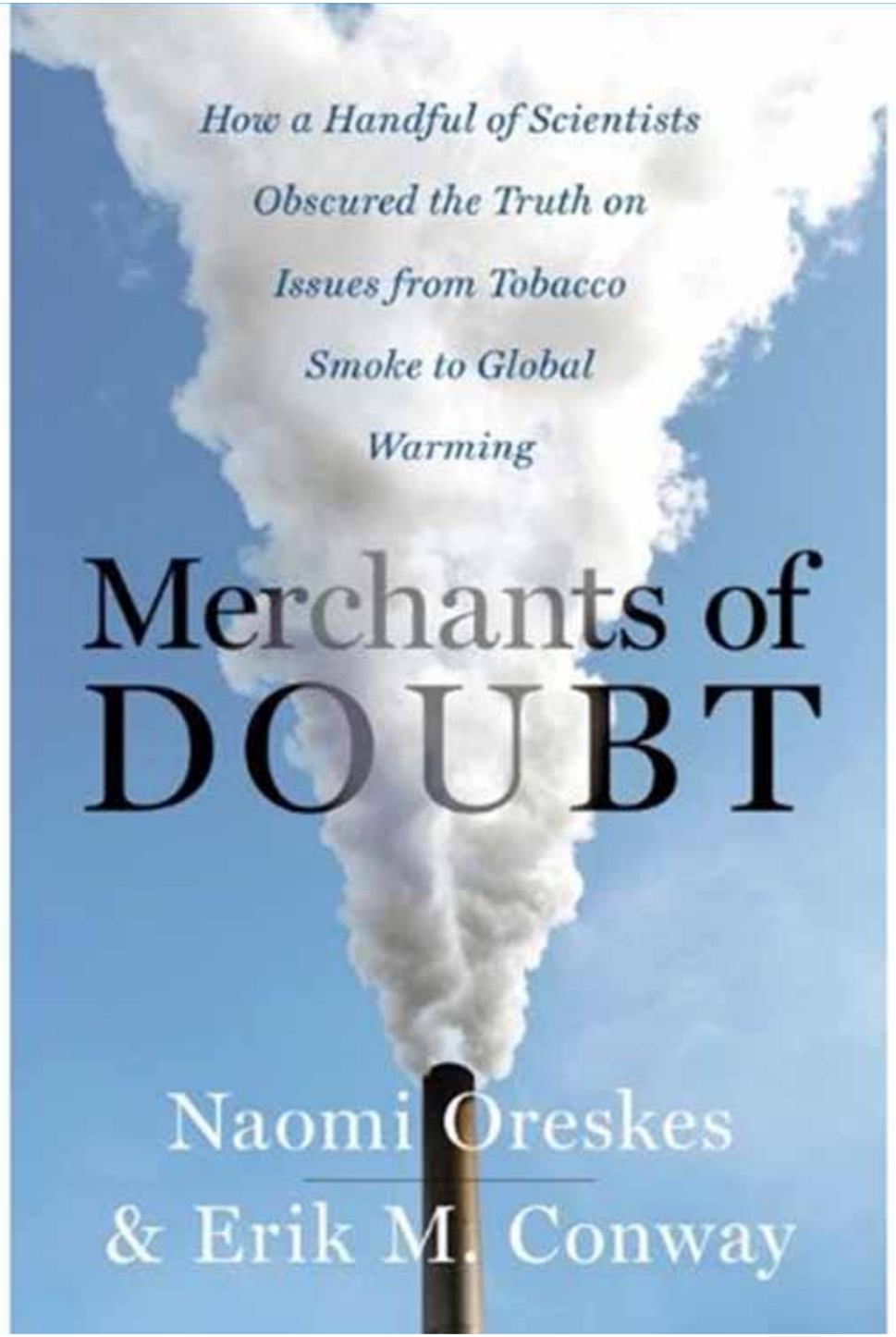
"But the conclusion I have reached is that the strong, immediate action on climate change advocated by the authors is an implication of their views on intergenerational equity; it isn't driven so much by the new climatic facts the authors have stressed."

‘These calculations indicate that, even with higher discounting, the Stern Review’s estimates of future benefits and costs imply that current mitigation passes a benefit-cost test.’

Global Climate Change: A Challenge to Policy, Kenneth J. Arrow, Economists’ Voice www.bepress.com/ev June, 2007

‘Note that these calculations rely on the Stern Review’s projected time profiles for benefits and its estimate of annual costs. Much disagreement surrounds these estimates, and further sensitivity analysis is called for. Still, **I believe there can be little serious argument over the importance of a policy of avoiding major further increases in combustion by-products**.’

Global Climate Change: A Challenge to Policy, Kenneth J. Arrow, Economists’ Voice www.bepress.com/ev June, 2007



Climate sceptics have bloated the uncertainties according to Oreskes and Conway

(as was done by tobacco lobbies)

According to Lindzen [the likely source of Crichton] the opposite is true. Global change = Eugenics at the beginning of the XX century.

Richard S. Lindzen, Science and Politics: Global Warming and Eugenics, from Risks, Costs, and Lives Saved, R.W. Hahn, editor, Oxford University Press, New York, 1996.

Vol 466|22 July 2010 nature

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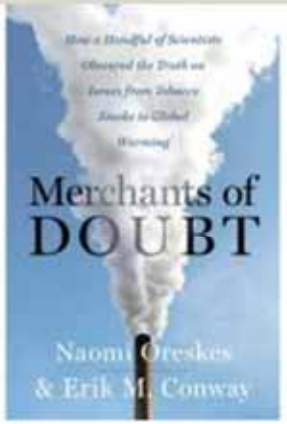
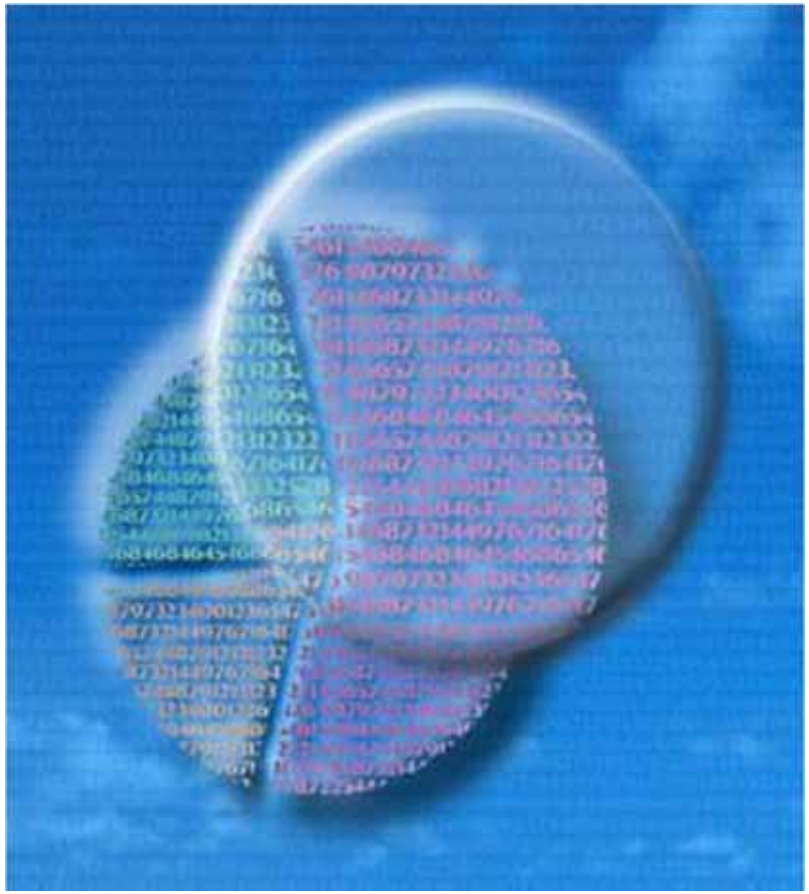


When doubt becomes a weapon

Brian Wynne wishes that a book on the vulnerability of scientific evidence to attack by ideologists had grappled more with the larger question of why science is such an easy target.

"Oreskes and Conway could have gone further in asking how scientific uncertainty should be interpreted in policy, and how science can be led to overreach itself in arbitrating public facts, meanings and norms."



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