

Course at the Joint Research Centre  
of Ispra:

# ‘Sensitivity analysis, sensitivity auditing and beyond’ Lesson 2: Sensitivity Auditing

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Autònoma de Barcelona (UAB)

Ispra March 29–31

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NEVER PARIBUS

Tweets by @AndreaSaltelli



andrea saltelli

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Sign and donate. What these people are doing is unique. [twitter.com/Jeroen\\_vdSluisj...](https://twitter.com/Jeroen_vdSluisj...)



24/11



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/...)



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



= more material on my web site



= discussion time

# Sensitivity auditing in the European Commission Impact Assessment toolbox

# EC impact assessment guidelines: what do they say 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 title 'Better Regulation'. A navigation menu on the left lists various topics, with 'Guidelines' highlighted. The main content area explains the purpose of the guidelines, their scope across the policy cycle, and provides links to related documents. A sidebar on the right includes a search bar, social media links, and a feedback section.

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European Commission

European Commission > Better Regulation > Guidelines

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**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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[http://ec.europa.eu/smart-regulation/guidelines/docs/br\\_toolbox\\_en.pdf](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.”

# 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.

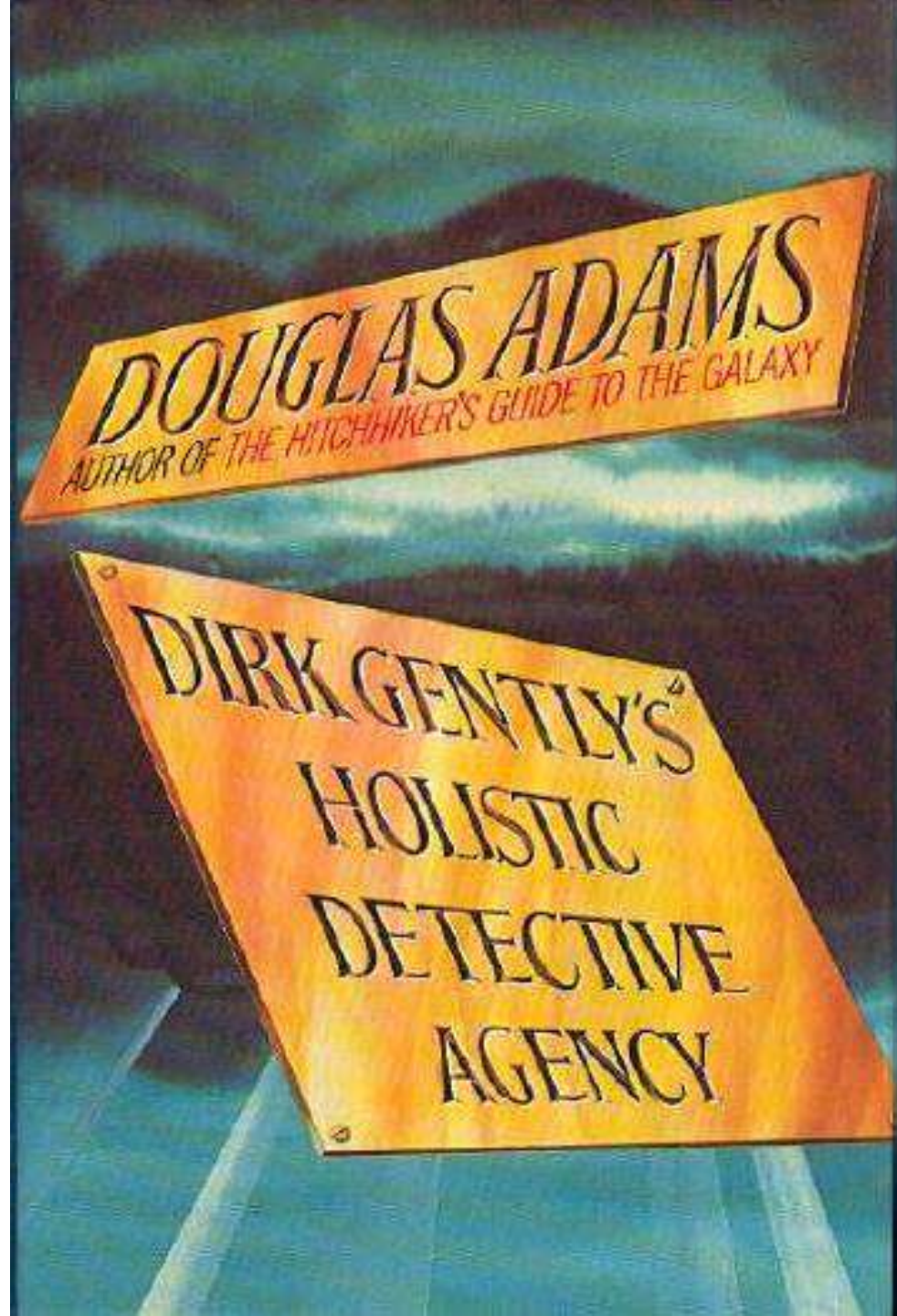
<http://issues.org/30-2/andrea/>



What is special about  
modelling?



Pocket Books 1987, p.69



“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.”

<<[...] 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.>>



George M.  
Hornberger

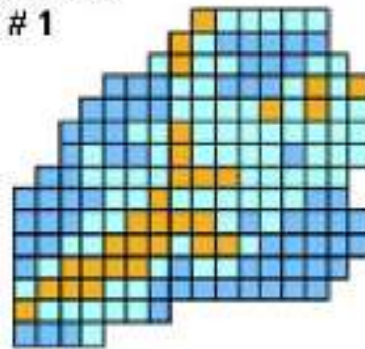
Hornberger, G.M., Spear, R.C., 1981. An approach to the preliminary analysis of environmental systems, Journal of Environmental Management 12, 7e18.

# Model structure uncertainty...

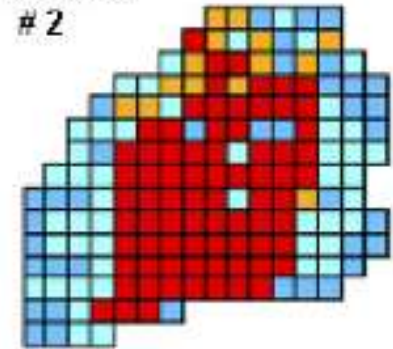
5 consultants, each using a different model were given the same question:  
*“which parts of this particular area are most vulnerable to pollution and need to be protected?”*

*(Refsgaard et al, 2006)*

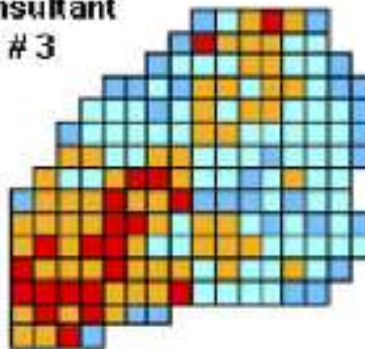
Consultant  
# 1



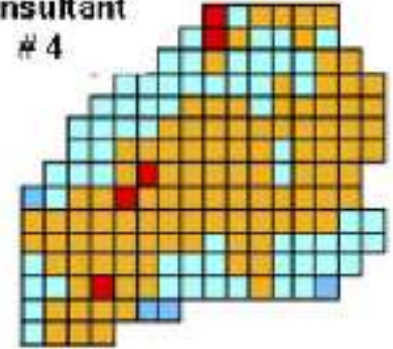
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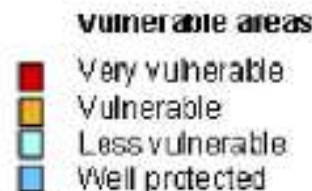
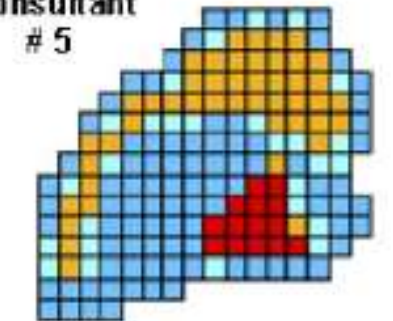
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Consultant  
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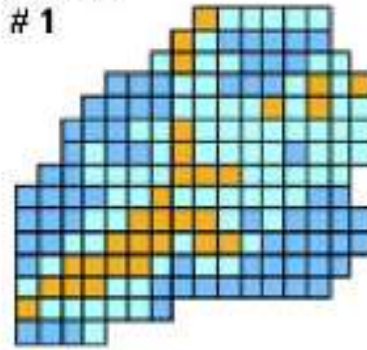


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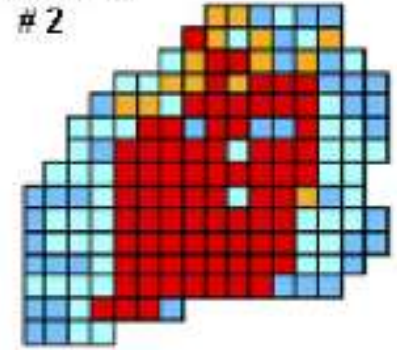




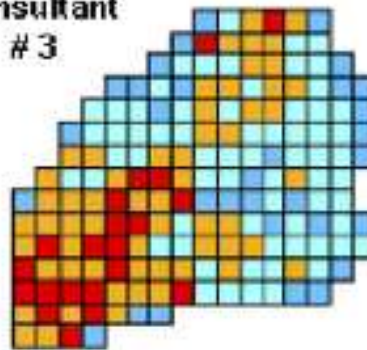
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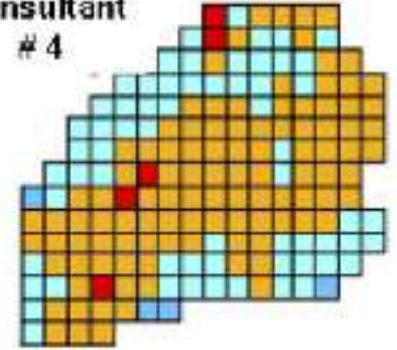
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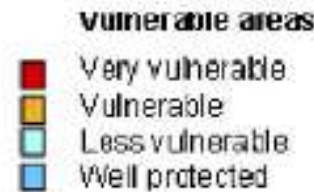
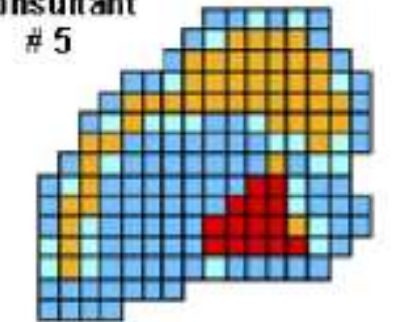
Consultant  
# 3



Consultant  
# 4



Consultant  
# 5



What is your take?  
What would you do?

Courtesy of Dr. Jeroen P. van der Sluijs, Centre for the Studies of the Sciences and the Humanities (SVT), University of Bergen (NO)

How to act upon such uncertainty

- **Bayesian** approach: 5 priors. A grid-cell being red with data (but need decisions now)
- IPCC approach: Lock the 5 conclusions and don't release them before they have been confirmed
- **Nihilist** approach: Dump the science on an other basis
- **Precautionary** robust approach
- **Academic bureaucracy** of consultant
- Select the consultant
- Real life approach: **no agenda**
- Post normal: explore the relevance of our ignorance: **working deliberately within imperfections**



Where do you belong?

Courtesy of Dr. Jeroen P. van der Sluijs, Centre for the Studies of the Sciences and the Humanities (SVT), University of Bergen (NO)



## 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 "injected" 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 Khiti-Eitman 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](http://www.sciencemag.org) on March 14, 2008

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

AAAS'S Web site, is a milestone: How can we reduce hunger and poverty, improve rural livelihoods, and facilitate equitable, environ-

\* [www.agassessment.org](http://www.agassessment.org)

community-based knowledge.

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

Watson, then the World Bank's chief scientist, 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

CREDIT: UNHCR/PH

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...

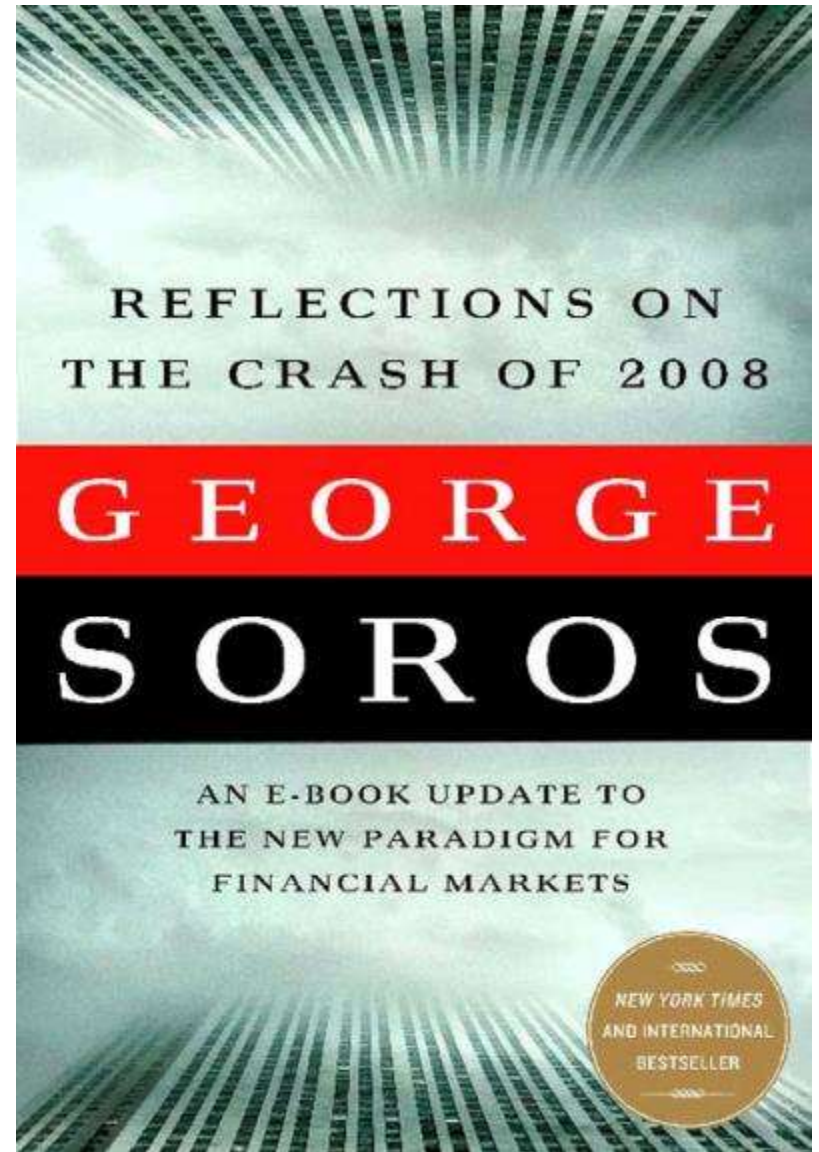


Nassim Nicholas  
Taleb, *The Black  
Swan*, Penguin,  
London 2007



Postulate of 'radical fallibility':

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



*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!

The rethorical question Keynes asks is (Keynes, 1940):

"It will be remembered that the seventy translators of the Septuagint were shut up in seventy separate rooms with the Hebrew text and brought out with them, when they emerged, seventy identical translations. Would the same miracle be vouchsafed if seventy multiple correlators were shut up with the same statistical material?"

Keynes, J. M. , 1940, On a Method of Statistical Business-Cycle Research. A Comment, The Economic Journal, Vol. 50, No. 197 (Mar., 1940), 154-156.

The case of the dynamic stochastic  
general equilibrium models (DSGE)

Pages 275–286

How dynamic stochastic general models (DSGE) were the subject of a hearing in the US Senate



Philip Mirowski

“an event in 2010 that was literally unprecedented in the history of economic thought in America with sworn testimony by economists such as Sidney Winter, Scott Page, Robert Solow, David Colander and V.V. Chari”



July 20, 2010 hearing on DSGE

[...] The basic stance of the hearings was defined in the opening comments by Chairman Brad Miller:

"According to the model's most devoted acolytes, the model's insights rival the perfect knowledge Paul described in the First Letter to the Corinthians; but unlike the knowledge Paul described, DSGE's insights are available in the here and now...



“...To be fair, DSGE and similar macroeconomic models were first conceived as theorists’ tools. But why, then, are they being relied on as the platform upon which so much practical policy advice is formulated? And what has caused them to become, and to stay, so firmly entrenched?”



Can model be used as part of a ritual?

The problem of legitimization – quantitative analysis as a rhetorical or ritual device – the story of Nobel prize laureate Kenneth Arrow:

*“The commanding general is well aware that the forecasts are no good. However, he needs them for planning purposes” (Szenberg, 1992)*

Szenberg, M. (ed.), 1992. Eminent Economists: Their Life Philosophies. Cambridge: Cambridge University Press.

## Why is it so easy to use models rhetorically?

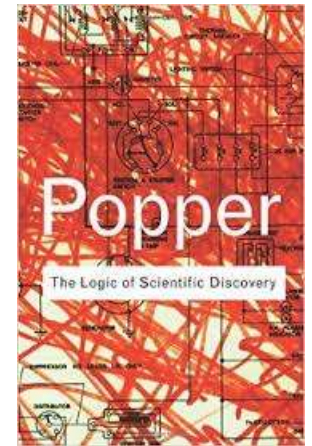
“In many cases, these temporal predictions are treated with the same respect that the hypothetic-deductive model of science accords to logical predictions. But this respect is largely misplaced”

Oreskes, N., 2000, Why predict? Historical perspectives on prediction in Earth Science, in *Prediction, Science, Decision Making and the future of Nature*, Sarewitz et al., Eds., Island Press, Washington DC



Naomi Oreskes

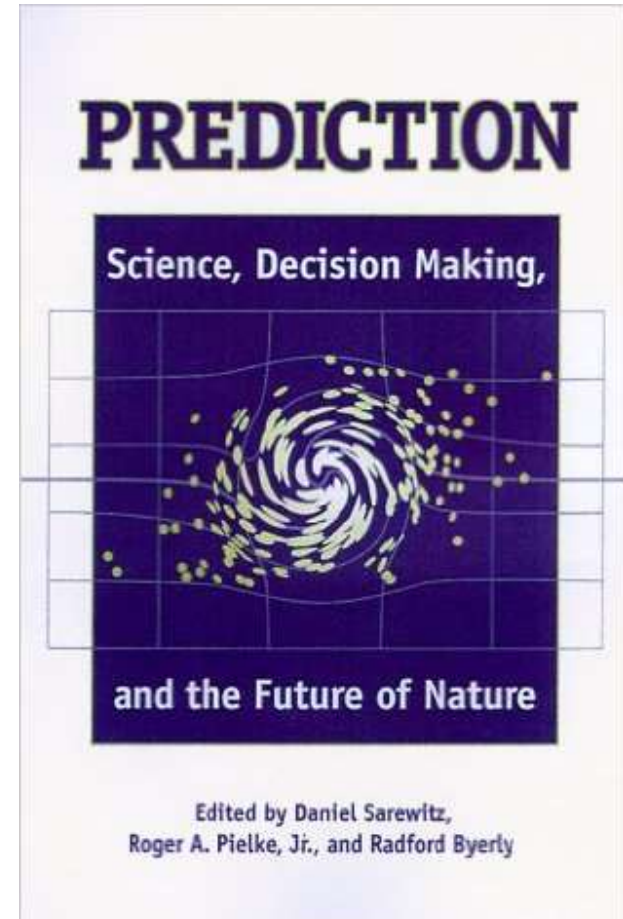
“[...] to be of value in theory testing, the predictions involved must be capable of **refuting** the theory that generated them.”



What when the ‘theory’ is not a law but a mathematical model?

“This is where predictions [...] become particularly sticky”

Oreskes, N., 2000, Why predict? Historical perspectives on prediction in Earth Science, in *Prediction, Science, Decision Making and the future of Nature*, Sarewitz et al., Eds., Island Press, Washington DC



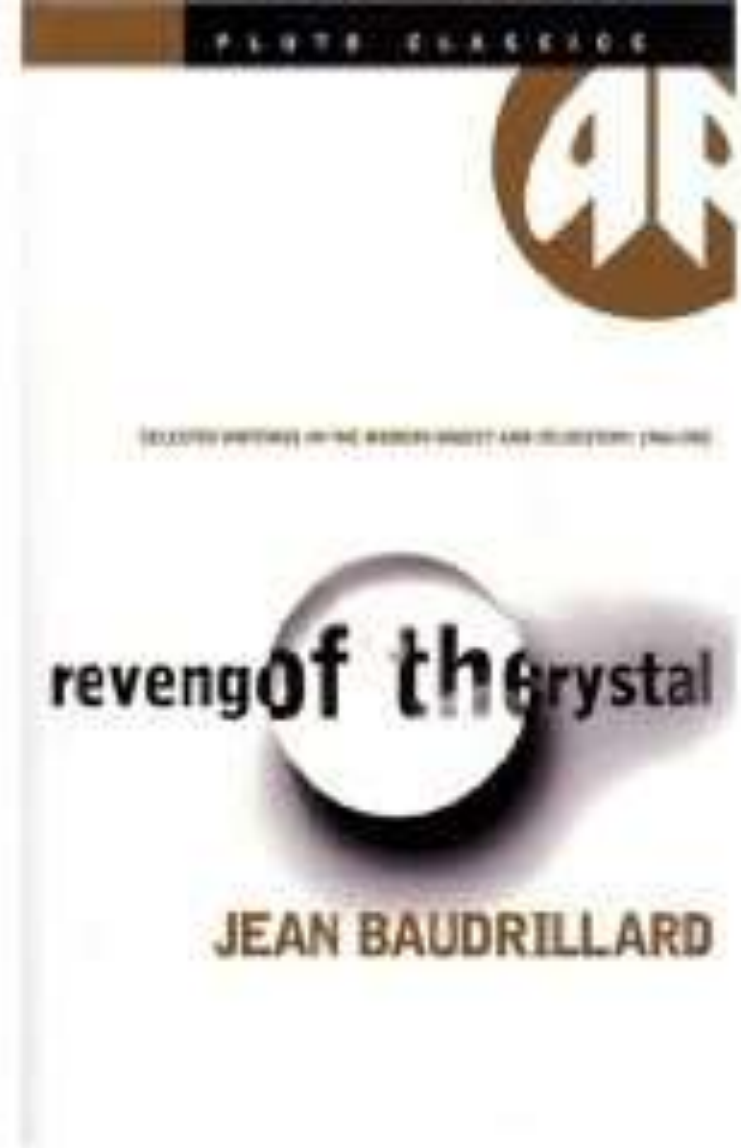
“[...] models are complex amalgam of theoretical and phenomenological laws (and the governing equations and algorithms that represent them), empirical input parameters, and a model conceptualization [...]



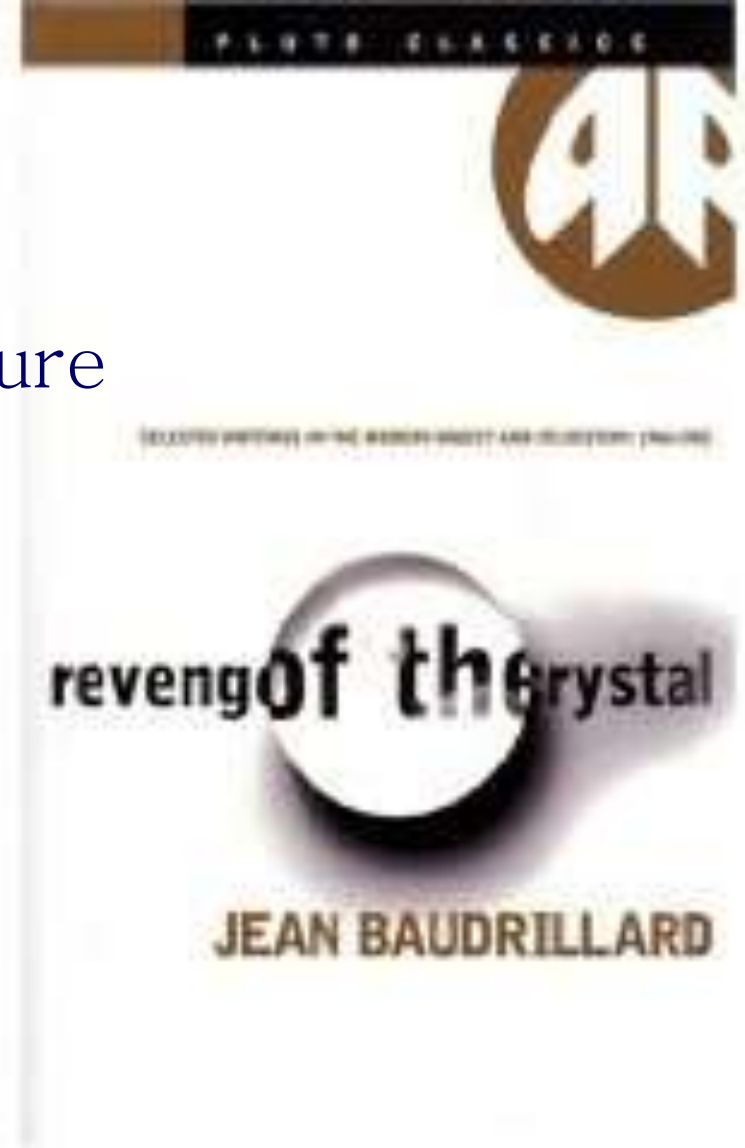
When a model generates a prediction, of what precisely is the prediction a test? The laws? The input data? The **conceptualization**? Any part (or several parts) of the model might be in error, and there is no simple way to determine which one it is”

An immense process of simulation has taken place throughout all of everyday life, in the image of those 'simulation models' on which operational and computer sciences are based.

Jean Baudrillard, *Revenge of the Crystal*, PLUTO Press 1999, p. 92



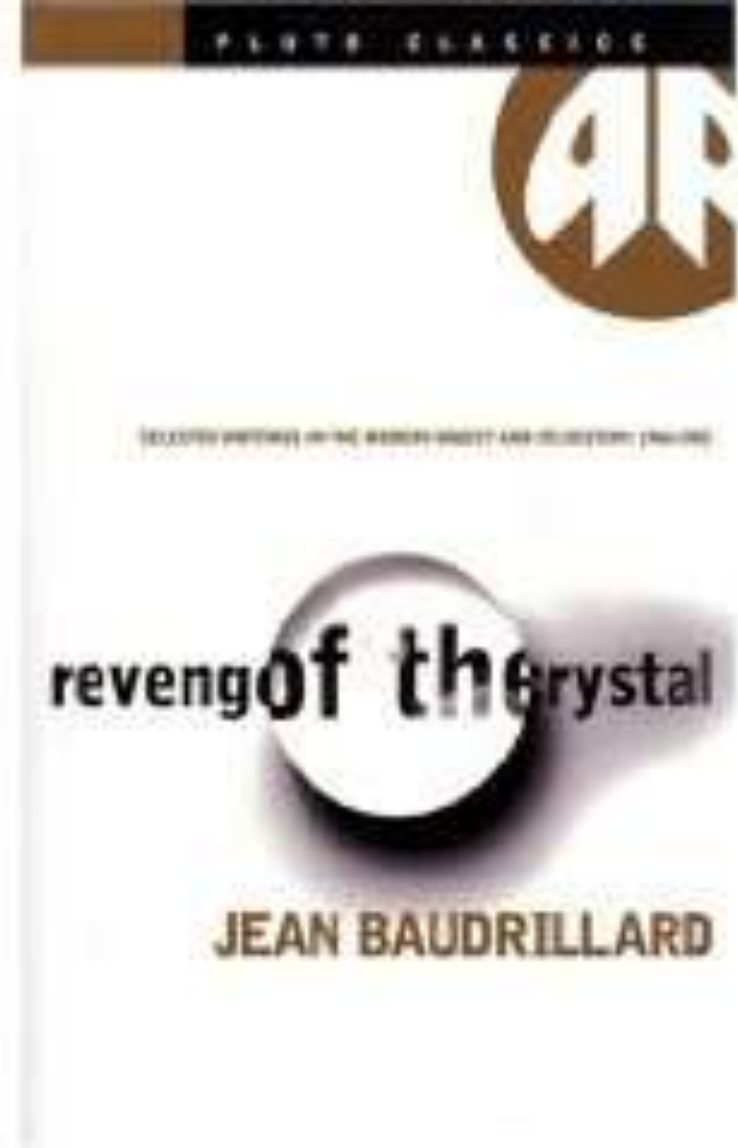
One 'fabricates' a model by combining characteristics or elements of the real; and, by making them 'act out' a future event, structure or situation, tactical conclusions can be drawn and applied to reality.



Jean Baudrillard, Revenge of the Crystal, PLUTO Press 1999, p. 92

It can be used as an analytic tool under controlled scientific conditions. In mass communication, this procedure assumes the force of reality, abolishing and volatilizing the latter in favour of that neo-reality of a model materialized by the medium itself.

Jean Baudrillard, *Revenge of the Crystal*, PLUTO Press 1999, p. 92



Robert Rosen's modelling relationship

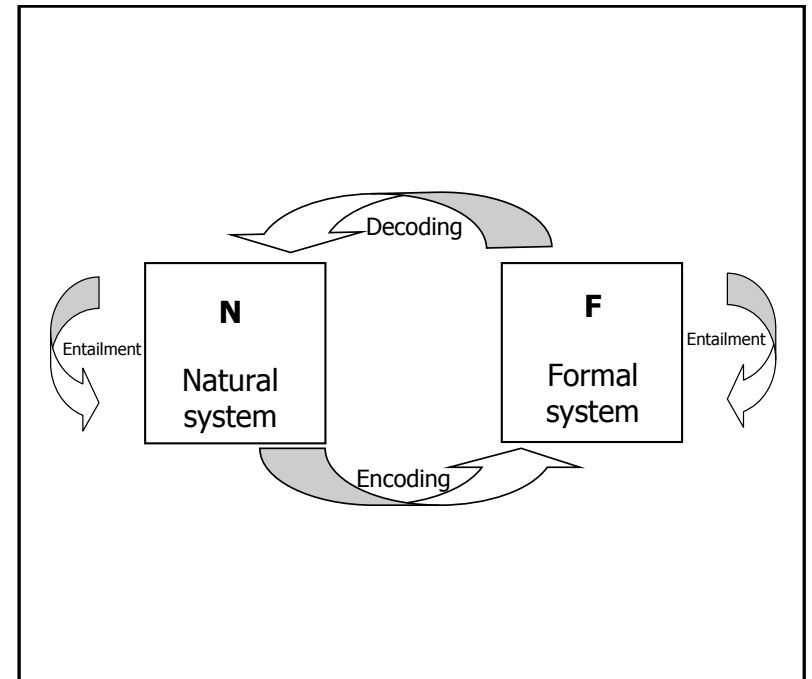
# LIFE ITSELF

*A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life*

ROBERT ROSEN

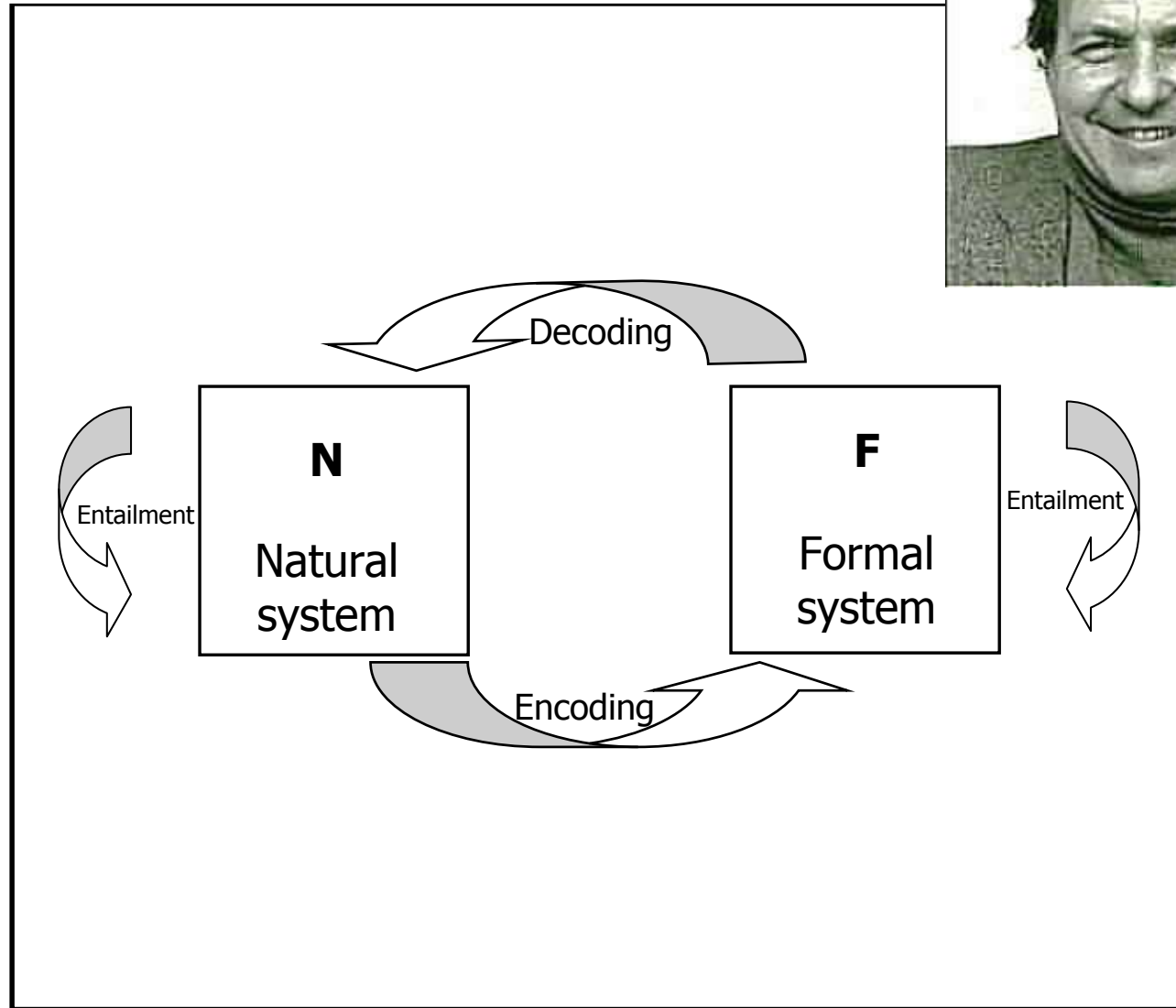


COMPLEXITY IN ECOLOGICAL SYSTEMS



# The critique of models

The  
nature of  
models,  
after  
R. Rosen



The model I am working on ...



... is special because ...

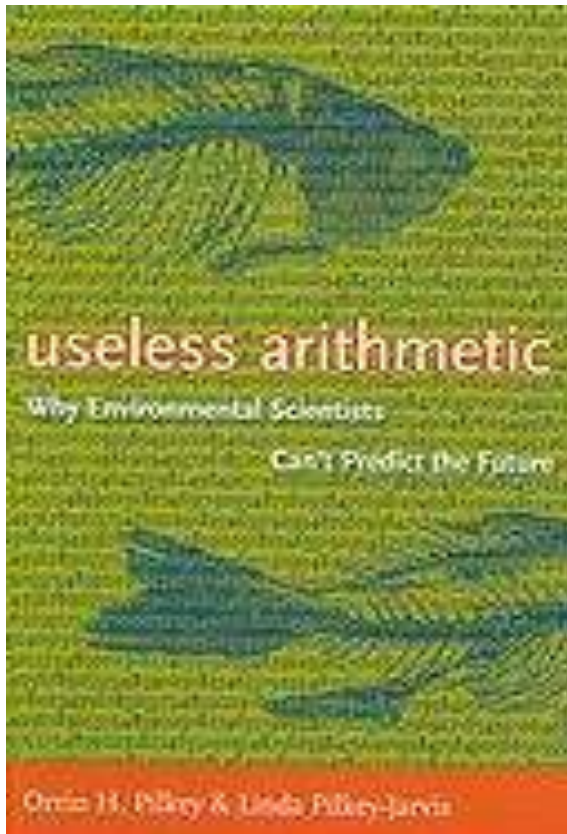
... is indeed rhetoric because...

# 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



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’

“Modellers could usefully consider the following principles:

“1. Before entering into contractual arrangements with third party consultants, consider the full spectrum of available models [...] [and check that] the complexity of the model is justified by the quality of information used to calibrate it, i.e. that a large **model is not being used rhetorically** to convey a spurious impression of accuracy.”

The screenshot shows the 'Better Regulation' webpage of the European Commission. The header includes the European Commission logo and the title 'Better Regulation'. Below the header, there is a navigation menu with links: Home, REFIT, Stakeholder consultations, Roadmaps / Inception Impact Assessments, Impact Assessment, Evaluation, Regulatory Scrutiny Board, and Guidelines. The 'Guidelines' section is expanded, showing sub-links: Better Regulation Guidelines, Better Regulation 'Toolbox', and Key documents. The main content area is titled 'Better Regulation Guidelines' and contains text explaining the purpose of the guidelines, their structure, and their basis in public consultation exercises. A sidebar on the right includes a search bar, social media links (Facebook, Twitter, YouTube), a 'Stay connected' section, 'Latest documents' (listing '13/05/2015 - Better Regulation Package'), and a 'Help us improve' section with a feedback form.

## 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

“[...] The models share a common approach. They pose the question: “How would we make our decision if we had complete knowledge of the world?” With such information you might make a detailed assessment [...]. But little of this knowledge exists. So you make the missing data up. You assume the future will be like the past [...]. The impression of rationality these procedures convey is spurious.”

“[...] If you do not know the answer to a question, the right response is not to make a number up, but to rethink and frame an alternative question that is capable of being answered.”



John Kay's approach is called 'Assumptions hunting' in Dutch circles ...



John Kay, Financial Times

Watch the videos from the workshop 'Significant digits. Responsible Use of Quantitative Information', Brussels, 11,9–10 June 2015.

<https://ec.europa.eu/jrc/en/event/conference/use-quantitative-information>



Philip Stark,  
University of Berkeley



Contents lists available at ScienceDirect

## Energy Policy

journal homepage: [www.elsevier.com/locate/enpol](http://www.elsevier.com/locate/enpol)



### On the contribution of external cost calculations to energy system governance: The case of a potential large-scale nuclear accident

Erik Laes<sup>a,\*</sup>, Gaston Meskens<sup>b</sup>, Jeroen P. van der Sluijs<sup>c</sup>



Contents lists available at ScienceDirect

## Environmental Modelling & Software

journal homepage: [www.elsevier.com/locate/envsoft](http://www.elsevier.com/locate/envsoft)



### A method for the analysis of assumptions in model-based environmental assessments

Penny Klopprogge<sup>a</sup>, Jeroen P. van der Sluijs<sup>a,b,\*</sup>, Arthur C. Petersen<sup>c</sup>



## On the contribution of external cost calculations to energy system governance: The case of a potential large-scale nuclear accident

Erik Laes <sup>a,\*</sup>, Gaston Meskens <sup>b</sup>, Jeroen P. van der Sluijs <sup>c</sup>

‘[...] calculation of the external costs of a potential large-scale nuclear accident [...] ‘An [analysis] resulted in a list of 30 calculation steps and assumptions’ ...

On the contribution of external cost calculations to energy system governance: The case of a potential large-scale nuclear accident

Erik Laes<sup>a,\*</sup>, Gaston Meskens<sup>b</sup>, Jeroen P. van der Sluijs<sup>c</sup>

[...]30 calculation steps and assumptions' ...

What would you do if this happened to you in the course of your PhD project?

What would you do if this happened to you in the course of a paid consultancy work?



Who should do the hunting? Implication of Rule 2 for participatory approaches introducing a worked example from flood management.



Lane, S. N., Odoni, N., Landström, C., Whatmore, S. J., Ward, N. and Bradley, S., 2011. “Doing flood risk science differently: an experiment in radical scientific method.” *Transactions of the Institute of British Geographers*, 36: 15–36.

# 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.

*Transactions of the Institute of British Geographers* © 2010 Royal Geographical Society (with the Institute of British Geographers)

[...] 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, ...

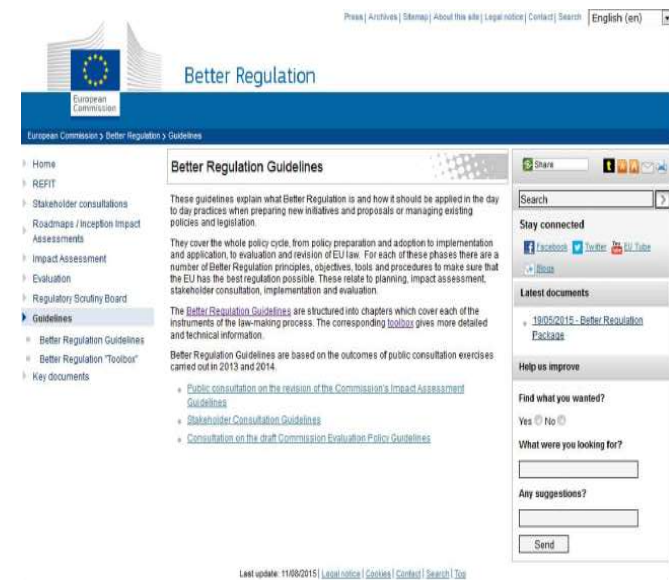


Years of modeling stream flow and cost/benefit ratios for flood protection structures had failed to consider an alternative intervention—upstream storage of flood waters—until local stakeholders were brought into the modeling process.

According to Lane and colleagues, upstream storage was neglected in the models because of the “use of a pit-filling algorithm that made sure that all water flows downhill”!

“Modellers could usefully consider the following principles:

2. Critically examine all model **assumptions**. Are there implicit or hidden assumptions which a third party might point to? Would it be possible to evaluate the impact of taking a different approach to tackle the issue?”



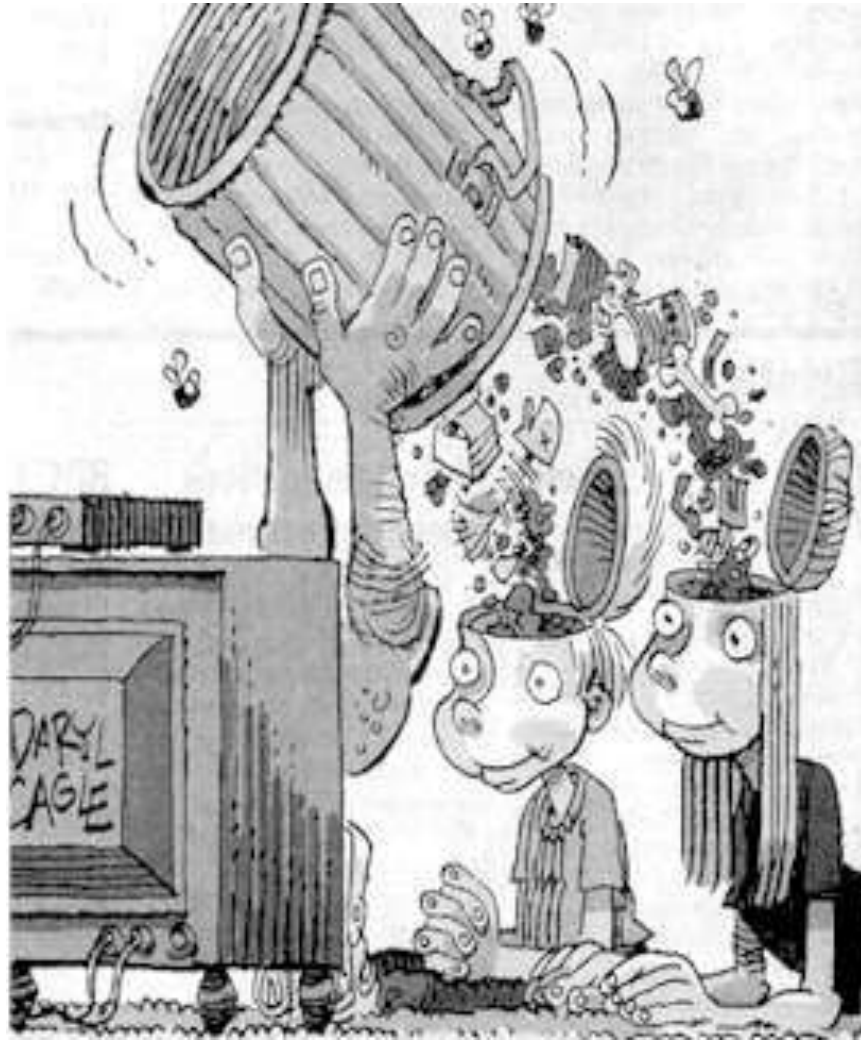


## Discussion points



- Am I haunted by a hidden assumptions, or by elephants in the room nobody else sees?

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



What is GIGO (Garbage In, Garbage Out) Science or pseudo-science “where uncertainties in inputs must be suppressed lest outputs become indeterminate” (Funtowicz and Ravetz, 1990)

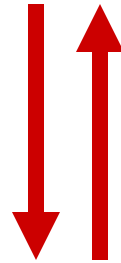


# Funtowicz & Ravetz's GIGO (Garbage In, Garbage Out) Science – or pseudo-science in this book

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



Funtowicz & Ravetz's GIGO (Garbage In, Garbage Out) Scienc – or pseudo-science – “where uncertainties in inputs must be suppressed least outputs become indeterminate”



**Leamer's** ‘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’.

“Modellers could usefully consider the following principles:

3. Be careful **not to over or under-estimate uncertainties** in model input parameters. [...] Where uncertainty is particularly difficult to quantify, it may be better to discuss it in qualitative terms rather than give a spurious impression of accuracy.”



RULE FOUR: find sensitivities before sensitivities find you;



## The RIVM media scandal (1999):

### Other Newspaper headlines:

“Environmental institute lies and deceits”

“Fuss in parliament after criticism on environmental numbers”

“The bankruptcy of the environmental numbers”

“Society has a right on fair information, RIVM does not provide it”

Jeroen van der Sluijs, A way out of the credibility crisis around model-use in Integrated Environmental Assessment, *Futures*, 34 (2002) 133–146.



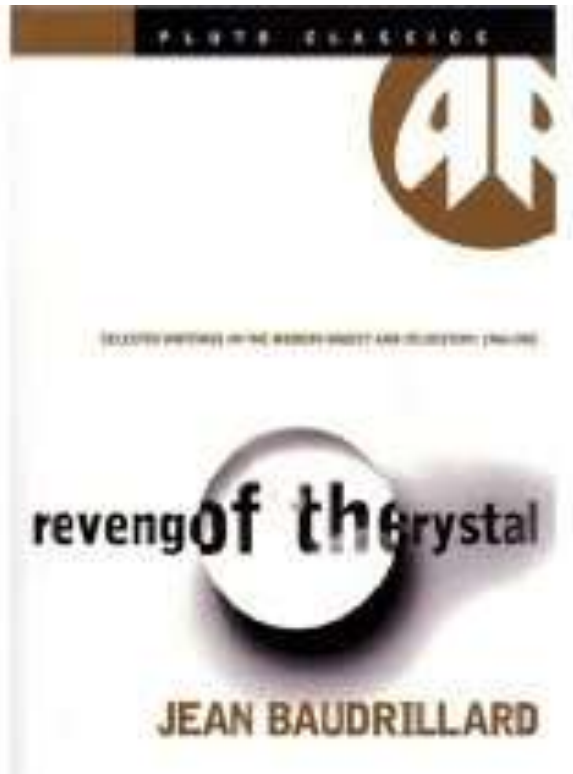


## The RIVM media scandal (1999):

*“RIVM over-exact prognoses based on **virtual reality** of computer models”*



Words used by French philosopher Jean Baudrillard in *Revenge of the Crystal*, PLUTO Press 1999, p. 92



Jeroen van der Sluijs, A way out of the credibility crisis around model-use in Integrated Environmental Assessment, *Futures*, **34** (2002) 133–146.

See also [www.nusap.net](http://www.nusap.net)

He co-authored the RIVM/MNP Guidance on Uncertainty Assessment and Communication (Leidraad).

# THE NEW YORKER

“Carmen Reinhart and Kenneth Rogoff [...] famous (now infamous) research that conservative politicians around the world had seized upon to justify pennypinching Policies ...”

John Cassidy, April 2013 issue

“... rising levels of government debt are associated with much weaker rates of economic growth, indeed negative ones ...”

It was instead a coding error uncovered by three researchers at the university of Michigan.



“In Britain and Europe, great damage has been done as a result.”

THE NEW YORKER

“The fact that software is commercial is no guarantee that it does what it's supposed to do” (Philip B. Stark)

<http://www.stat.berkeley.edu/~stark/Preprints/auditingPosition09.htm#excel>

Philip B. Stark



# Perils of placing faith in a thin theory



By Wolfgang Münchau April 21, 2013

Reinhart and Rogoff told policy makers what they wanted to hear

John Kenneth Galbraith [about] Milton Friedman: “Milton’s misfortune was that his policies had been tried.

[...]

As for Profs Reinhart and Rogoff, I suspect that they, too, will be mostly remembered for the fact that their policies have been tried”

# RULE FOUR: find sensitivities before sensitivities find you;

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 case of Stern's Review – Technical Annex to postscript



William Nordhaus,  
University of Yale



Nicholas Stern, London  
School of Economics

Stern, N., Stern Review on the Economics of Climate Change.  
UK Government Economic Service, London,  
[www.sternreview.org.uk](http://www.sternreview.org.uk).

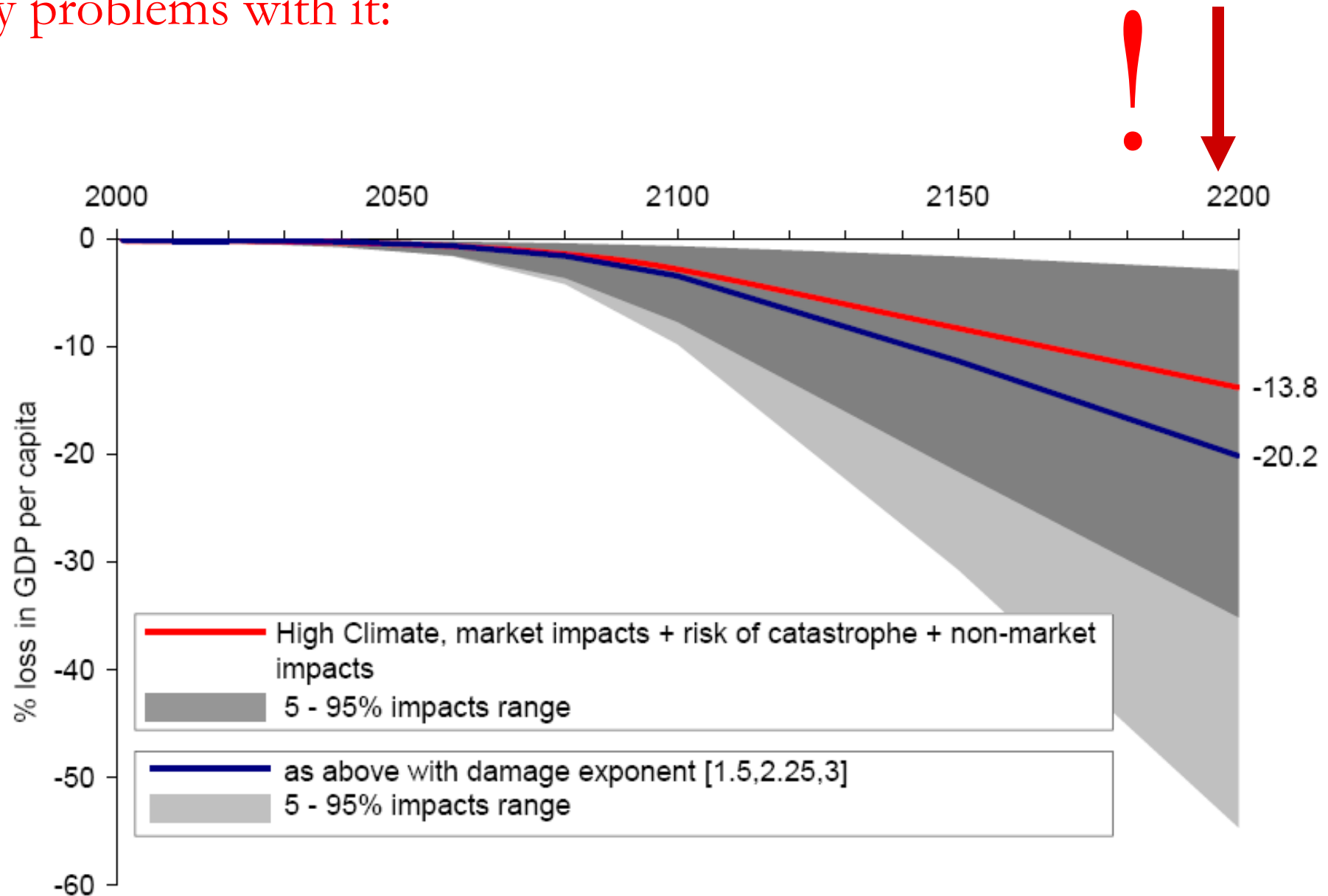
Nordhaus W., Critical Assumptions in the Stern Review on  
Climate Change, *SCIENCE*, 317, 201-202, (2007).

RULE FOUR: find sensitivities before sensitivities find you;

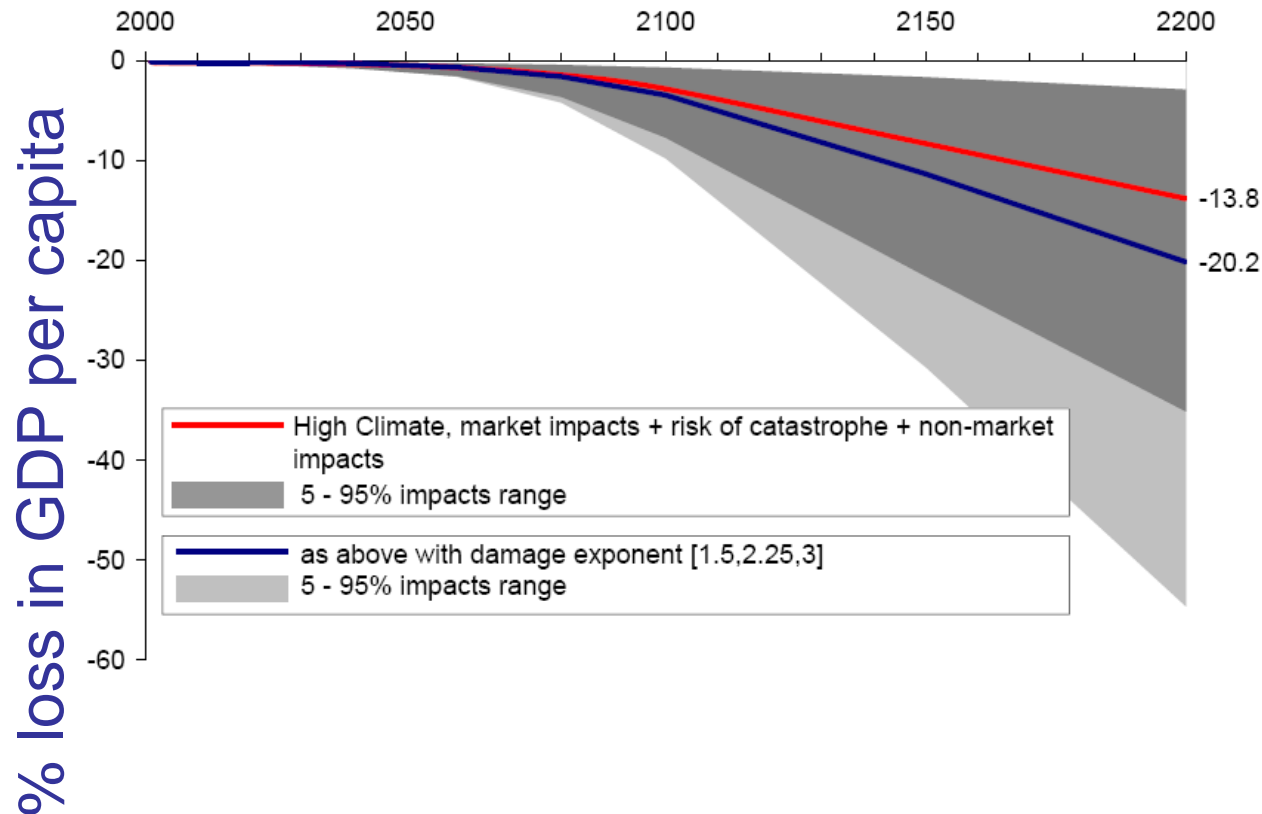
The Stern - Nordhaus exchange on *SCIENCE*

- 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:

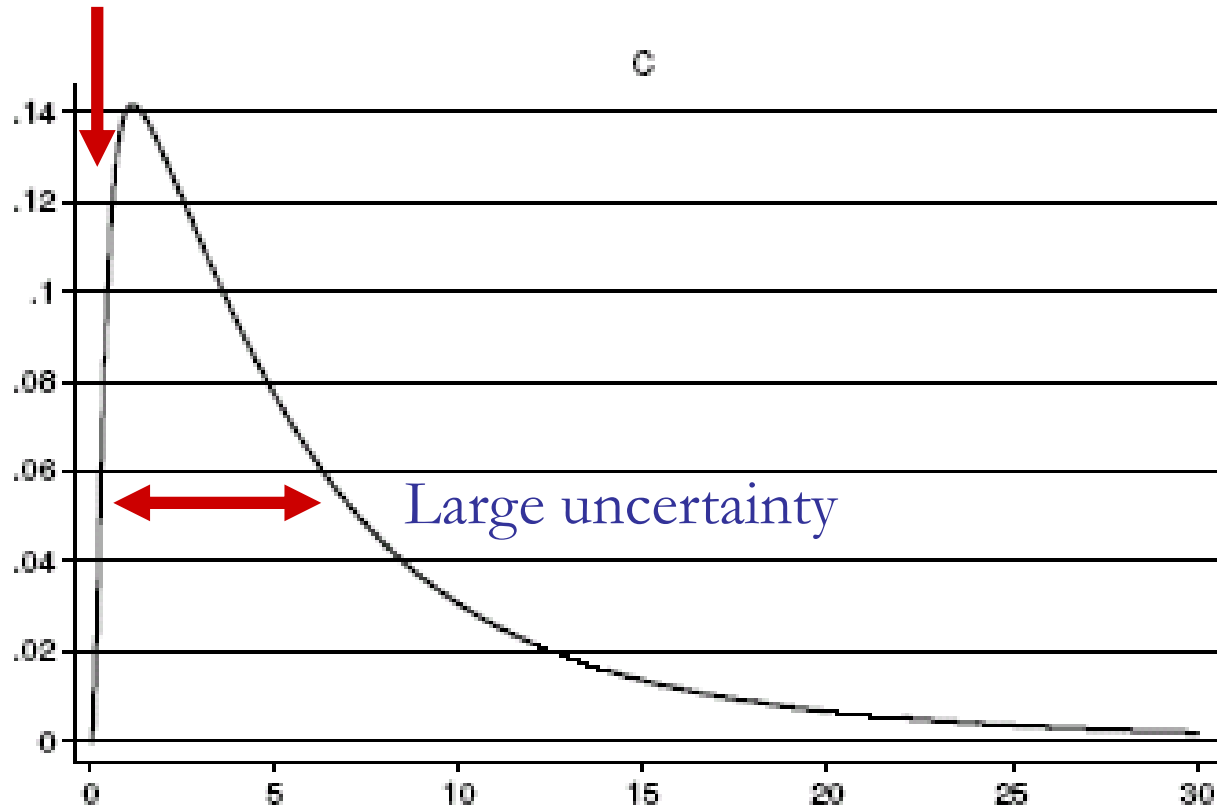


... but foremost Stern says:  
changing assumptions → important effect  
when instead he should admit that:  
changing assumptions → all changes a lot



# How was it done? A reverse engineering of the analysis

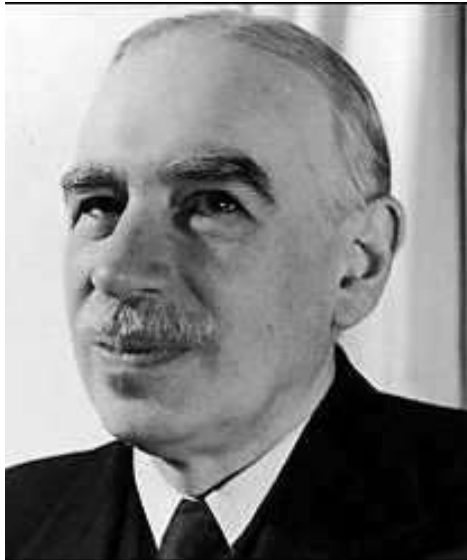
Missing points



% loss in GDP per capita

RULE FOUR: find sensitivities before sensitivities find you;

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



... precisely wrong

... and the story continues to these days ...



NATURE | CORRESPONDENCE



## Modelling: Climate costing is politics not science

Andrea Saltelli

Nature 532, 177 (14 April 2016) | doi:10.1038/532177a

Published online 13 April 2016

Saltelli, A., Stark, P.B., Becker, W., and Stano, P., 2015, Climate Models As Economic Guides Scientific Challenge or Quixotic Quest?, Issues in Science and Technology, Volume XXXI, Issue 3, spring 2015.

Saltelli, A., Funtowicz, S., Giampietro, M., Sarewitz, D., Stark, P.B., van der Sluijs, J.P., 2016, Climate costing is politics not science, Nature, 14 April, 532, 177.



# Costing climate?

ANDREA SALTELLI  
PHILIP B. STARK  
WILLIAM BECKER  
PAWEL STANO



## Climate Models as Economic Guides Scientific Challenge or Quixotic Quest?

The uncertainties associated with mathematical models that assess the costs and benefits of climate change policy options are unknowable. Such models can be valuable guides to scientific inquiry, but they should not be used to guide climate policy decisions.

An audacious study:

*Foreword by Michael R. Bloomberg,  
Henry M. Paulson, and Thomas F. Steyer*



**ECONOMIC RISKS  
OF  
CLIMATE CHANGE**



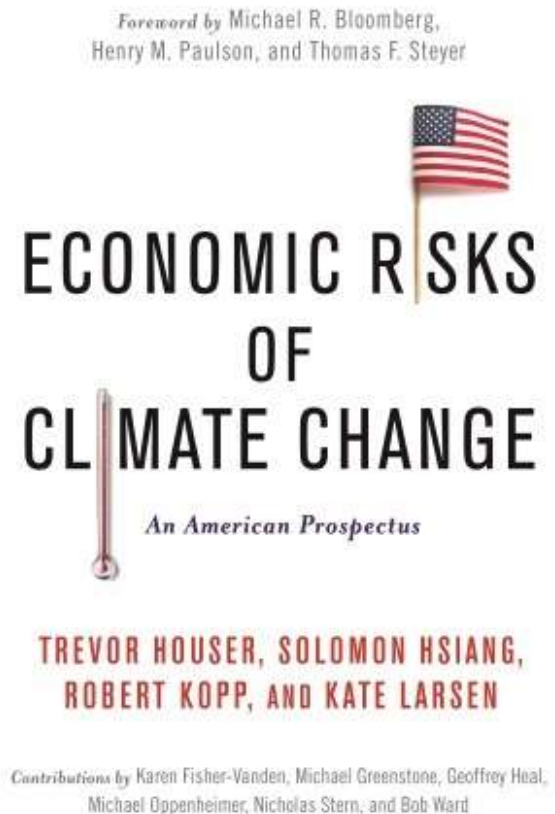
*An American Prospectus*

**TREVOR HOUSER, SOLOMON HSIANG,  
ROBERT KOPP, AND KATE LARSEN**

*Contributions by Karen Fisher-Vanden, Michael Greenstone, Geoffrey Heal,  
Michael Oppenheimer, Nicholas Stern, and Bob Ward*

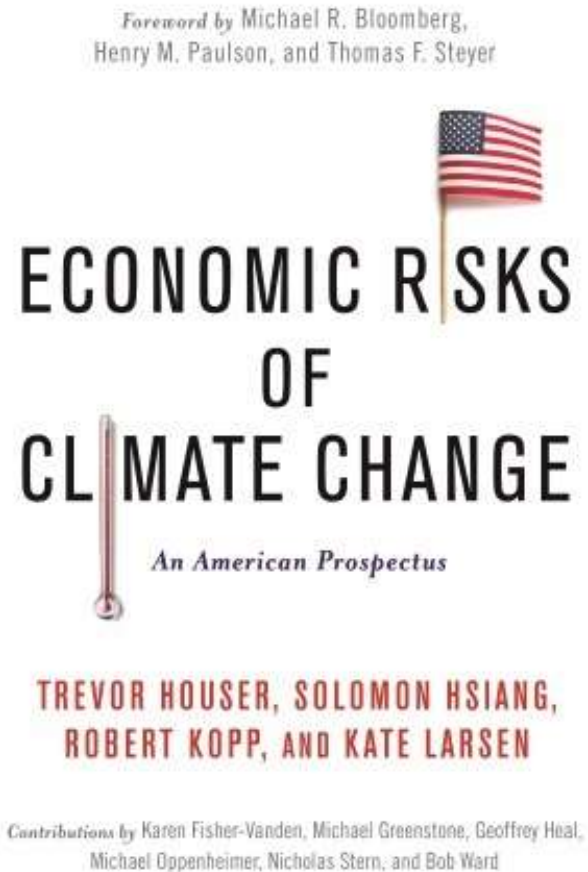
“[...] the report forecasts—at the level of individual counties in the U.S.—energy costs and demand, labor supply, mortality, violent crime rates, and real estate property prices up to the year 2100 [...]”

Climate Models  
as  
Economic Guides  
Scientific Challenge  
or  
Quixotic Quest?

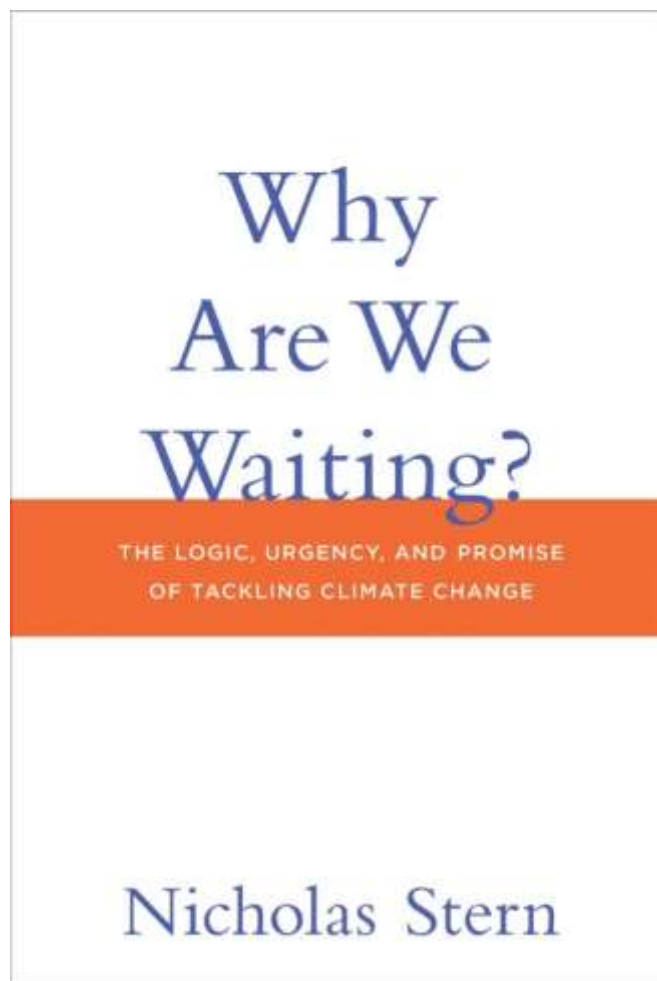


“The report presents the amount of computer power and data generated as evidence of the scientific legitimacy of the enterprise. The authors note, however, that out of an abundance of caution they did not model deterioration in cognitive performance as temperatures rise”

Climate Models  
as  
Economic Guides  
Scientific Challenge  
or  
Quixotic Quest?



Next comes the latest (2015) book of Nicholas Stern ...



... advocating for better integrated assessment models (IAM)

# THE LOGIC, URGENCY, AND PROMISE OF TACKLING CLIMATE CHANGE

## Excerpts

“Integrated assessment models have produced valuable insights” p. 139

“In Chapter six of the Stern review we made use of the PAGE model” p. 345

## THE LOGIC, URGENCY, AND PROMISE OF TACKLING CLIMATE CHANGE

... After a list of criticism moved to the realism of Integrated Assessment Models:

“[...] the point is that estimates based on these models are very sensitive to assumptions and are likely to lead to gross underestimation” p.139

Things to be incorporated in ‘formal modelling’ [sic]

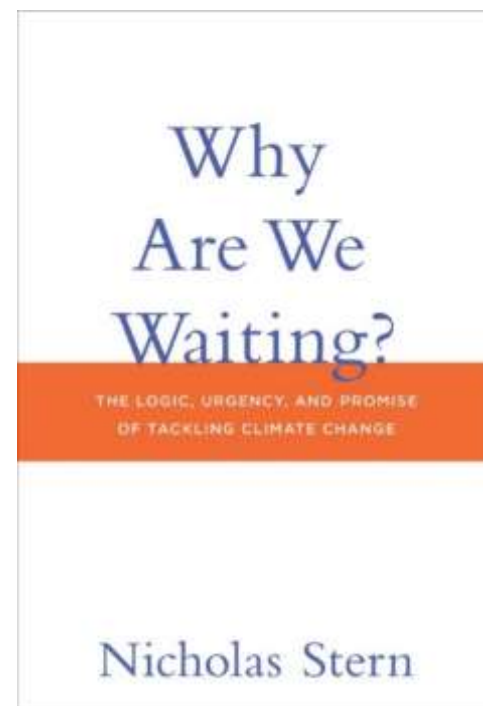
“Damage to social, organizational or environmental capital [...]

Damage to stock of capitals and land [...]

Damage to overall factor productivity [...]

Damage to learning and endogenous growth”, p. 145

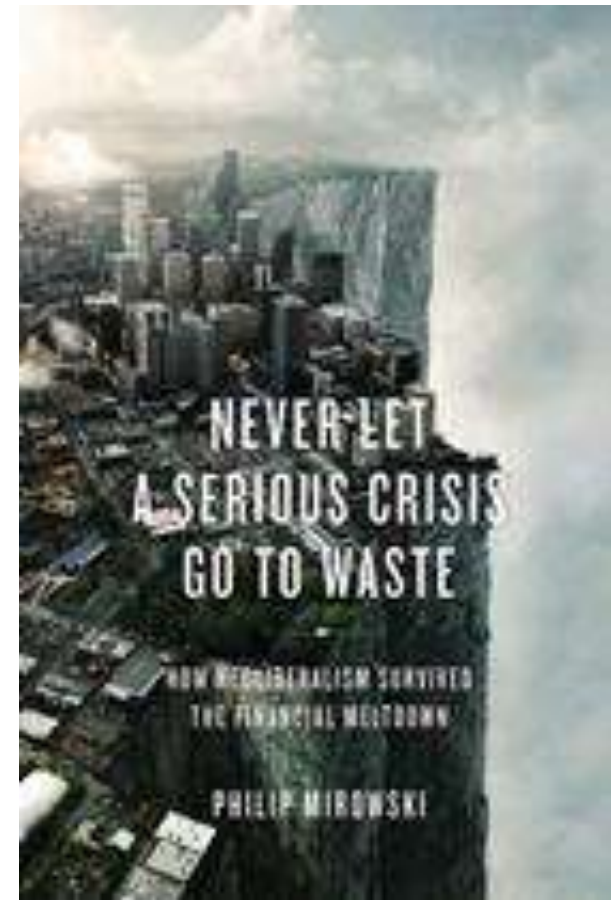
‘formal modelling’ as to produce ‘numbers’?



The book of N. Stern suggests using different mathematical models, including dynamic stochastic general equilibrium models.



Philip Mirowski



See Philip Mirowski's book for a damaging critique of DSGE as used in economics ... inquiries by the US senate and the Queen of the England about their failure to predict the crisis ...

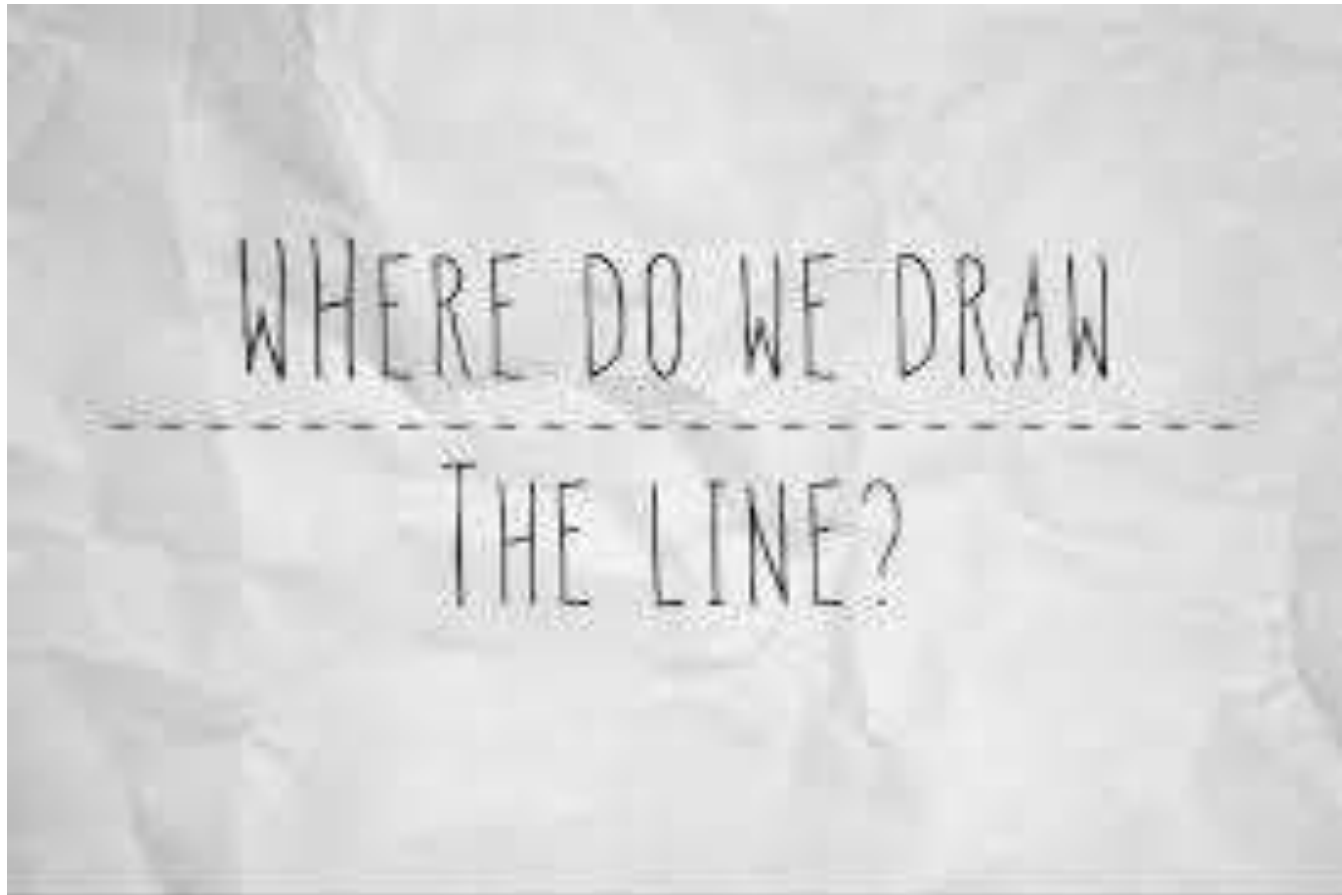
Everybody in the profession knows that DSGE work under the economists' standard 'caeteris paribus' hypothesis (=all the rest being equal)



But

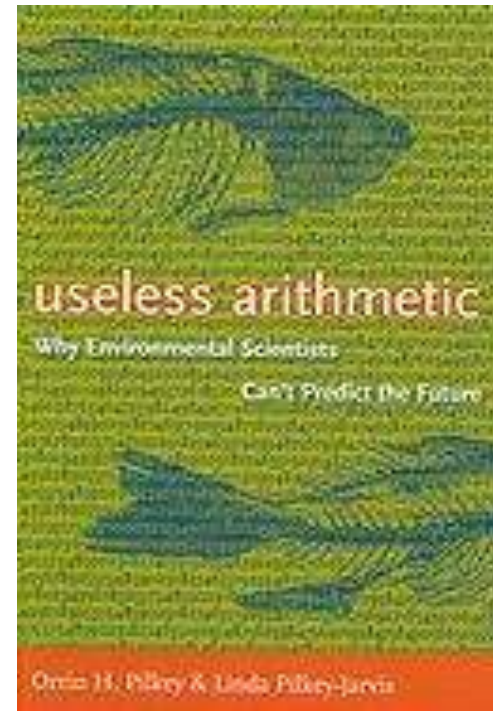
Caeteris are  
never paribus

Mathematical modelling of climatic change  
(terra infirma) and its cost to society (terra  
incognita):



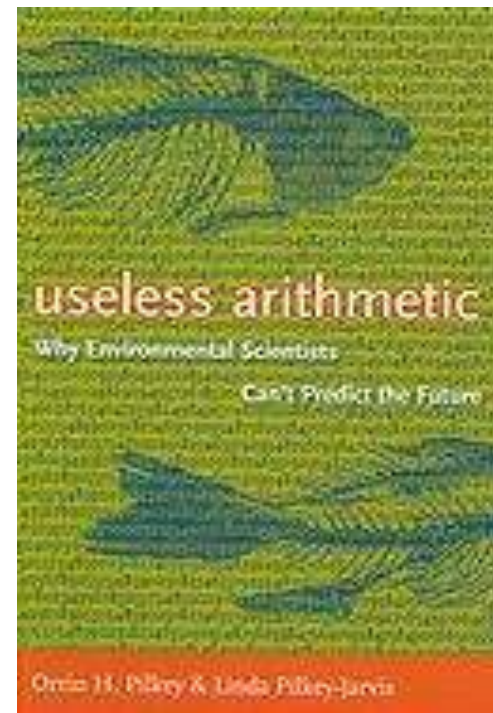
Pilkey and Pilkey-Jarvis (2007:86) climate-sceptics' work would be harder if:

“[...] 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.”



Pilkey, O.H. and Pilkey-Jarvis, L., 2007. Useless Arithmetic. Why Environmental Scientists Can't Predict the Future, Columbia University Press, New York.

“[...] 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 sea-level position.”



## Discussion points



- Climate costing is useful because ...

## Discussion points



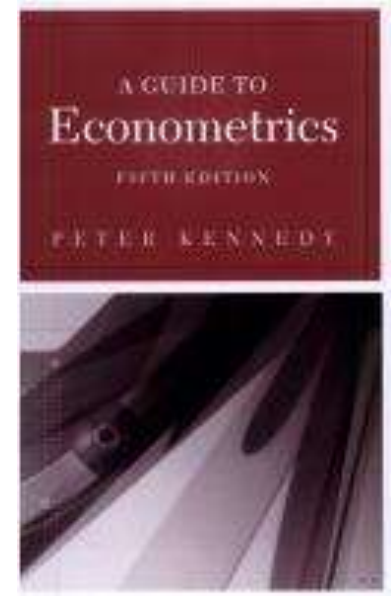
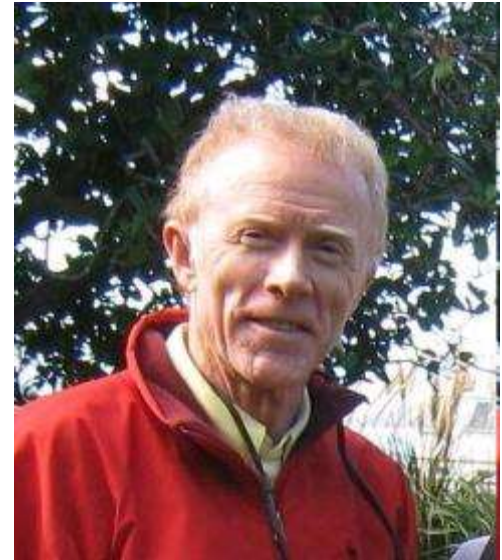
- Can I recall an instance where uncertainties have been either amplified or deflated instrumentally?

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:

<<Thou shall confess in the presence of  
sensitivity.

Corollary: Thou shall anticipate criticism >>



# RULE FIVE: aim for transparency

## Doubts raised over Europe's green energy plan

Hill of questions/ from advisers

Economic model lacks transparency

By Peter Clark in London

The credibility of a European energy review has been cast into doubt by specialists. Advisers who are close to the review have come up to 1000 questions in an economic model used by a single think tank, severely questioning its accuracy and reliability.

The energy experts have "raised a host of questions" on how the European Commission's plan of a new transparent model could affect the review, according to a leaked report by advisers close to Brussels. The report, leaked to the "Energy Institute" last month.

The analysis, which is being sent to France, is being sent to the National Technical University of Athens and is designed to show how the use of different energy sources affects the world economy.

The European Commission has asked it for advice on how to help guide the EU's energy policy. But advisers' critics complain that the commission is supposed to question because the model is extremely complex. One critic, Professor, University of London, has called for the Commission to use other, more transparent models.

The forthcoming review of the energy market, which will involve the effect of meeting the growing demand for energy, will be a major test for the EU's green energy. The commission's model, which is being sent to France, has been sent to the National Technical University of Athens and is designed to show how the use of different energy sources affects the world economy.

"There are considerable doubts about the use of the EU's green energy policy," says the report, which is being sent to France. The report, which is being sent to France, is being sent to the National Technical University of Athens and is designed to show how the use of different energy sources affects the world economy.



A rising plant in Germany: the credibility of plans to cut CO2 emissions has been called into question by experts

national energy review, as the International Energy Agency.

There were also questions on "the costs of different technologies" and "the complexity of power generation by companies but not by individuals".

The review also concerns the "lack of transparency of the French work, and in particular the review itself in the absence of the review".

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

The review also includes several questions of the model, says the report, which is being sent to France.

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

The commission is the independent party which reviews the results. This is a substantial matter for the Commission, but it is not

of the review process, as it is not a review process. The review is the review of the review.

The review is the review of the review. The review is the review of the review. The review is the review of the review.

France, which is being sent to France, is being sent to the National Technical University of Athens and is designed to show how the use of different energy sources affects the world economy.

A spokesman for the energy commission, Charles Oettinger, said the review was important to the commission's work.

And Oettinger has been an energy expert for many years and has held positions in the energy sector.

## 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, according to a leaked report by energy specialists chosen by Brussels to advise on the forthcoming “Energy Roadmap to 2050”

FT 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.”

---

## Part IX

# Office of Management and Budget

---

**Guidelines for Ensuring and Maximizing  
the Quality, Objectivity, Utility, and  
Integrity of Information Disseminated by  
Federal Agencies; Notice; Republication**



The OMB about  
transparency

<http://www.whitehouse.gov/omb/inforeg/>

## RULE FIVE: aim for transparency

[models should be made available to a third party so that it can] use the same data, computer model or statistical methods to replicate the analytic results reported in the original study.

[...] The more important benefit of transparency is that the public will be able to assess how much an agency's analytic result hinges on the specific analytic choices made by the agency.

Friday, February 22, 2002

Graphic - Federal Register, Part IX

**Office of Management and Budget**

Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies; Notice; Republication

<http://www.whitehouse.gov/omb/inforeg/>

This was 2002

# <sup>20</sup>House Republicans Aim To Limit Power Of Environmental Protection Agency

The Huffington Post | by [Robin Wilkey \(/robin-wilkey\)](#)

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

This is 2014



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.

“Secret Science Reform Act of 2014 [...] to prohibit the Environmental Protection Agency (EPA) from proposing, finalizing, or disseminating [a risk, exposure, or hazard assessment, criteria document, standard, limitation, regulation, regulatory impact analysis, or guidance] unless all scientific and technical information relied on to support such action is specifically identified and publicly available online in a manner sufficient for independent analysis and substantial reproduction of research results”

<http://beta.congress.gov/bill/113th-congress/house-bill/4012>  
Accessed February 2017

The bill died in the Senate in 2015 after winning House approval.

But (February 2, 2017):



The screenshot shows the homepage of InsideClimate News. The header includes a navigation bar with links: HOME, ABOUT, CONTACT, WHISTLEBLOWERS, AWARDS, SUBSCRIBE, DONATE, JOBS, and social media icons for Facebook, Twitter, and RSS. Below this is a green banner with the site's name 'inside climate news' and a list of categories: News, Investigations, Topics, Today's Climate, Clean Economy, Documents, Infographics, and Membership. A tagline below the banner reads: 'A Pulitzer Prize-winning, non-profit, non-partisan news organization dedicated to covering climate change, energy and the environment.' The main headline is 'Rep. Lamar Smith Launches New Assault on EPA's 'Secret Science''. Below the headline is a sub-headline: 'Head of the House Science Committee calls a hearing to inquire into how the agency uses science in its decisions, part of his long battle against the agency's work.' To the left of the sub-headline is a small circular profile picture of David Hasemyer, followed by the text 'BY DAVID HASEMYER' and a 'Follow @DavidHasemyer' button. To the right of the sub-headline is a 'Subscribe to InsideClimate News' form with fields for 'FIRST NAME', 'LAST NAME', and 'EMAIL', and a green 'SUBSCRIBE' button. The date 'FEB 2, 2017' is visible at the bottom left of the article section.

inside climate news

HOME ABOUT CONTACT WHISTLEBLOWERS AWARDS SUBSCRIBE DONATE JOBS

News Investigations Topics Today's Climate Clean Economy Documents Infographics Membership

A Pulitzer Prize-winning, non-profit, non-partisan news organization dedicated to covering climate change, energy and the environment.

HOME

## Rep. Lamar Smith Launches New Assault on EPA's 'Secret Science'

Head of the House Science Committee calls a hearing to inquire into how the agency uses science in its decisions, part of his long battle against the agency's work.

BY DAVID HASEMYER [Follow @DavidHasemyer](#)

FEB 2, 2017

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“Hearing titled ‘Making the EPA Great Again’ [...] critics say it's just a launch pad to revive his science reform legislation [the secret science bill]”

<https://insideclimatenews.org/news/02022017/lamar-smith-epa-house-science-committee>

“Modellers could usefully consider the following principles:

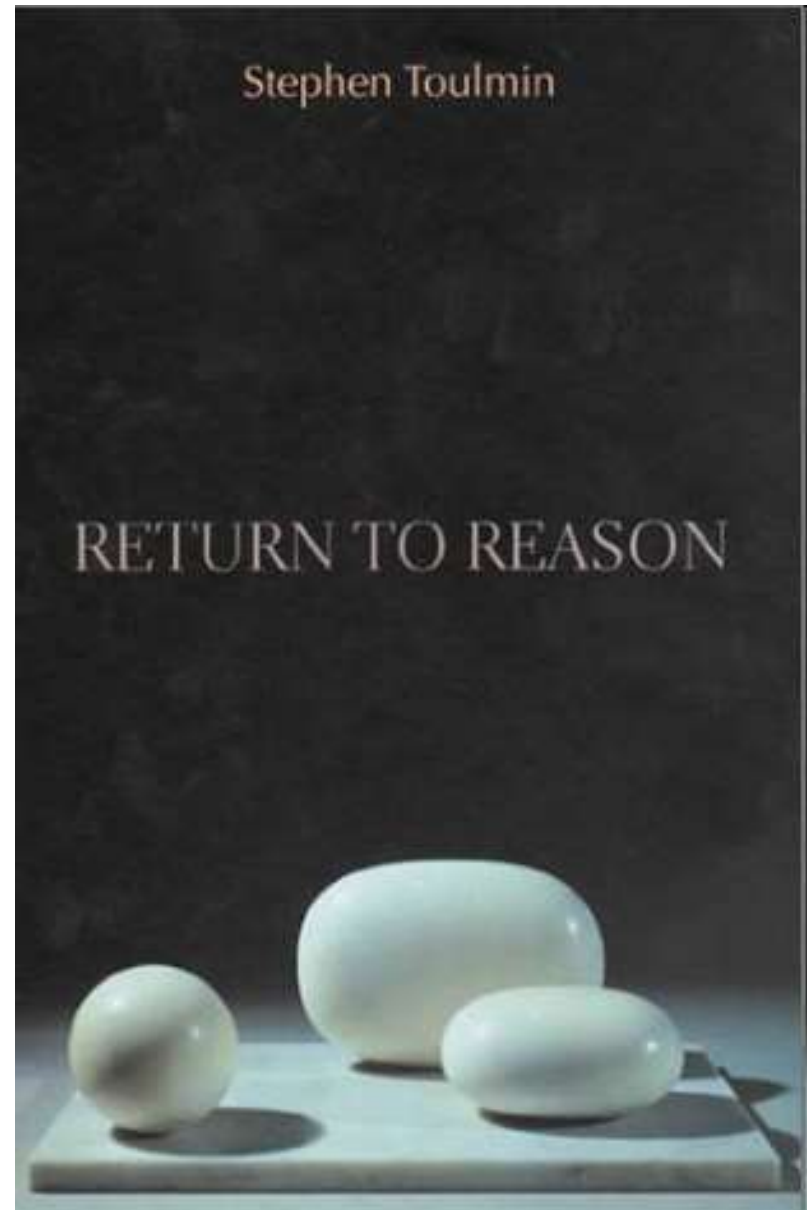
4. Aim for transparency – when relevant and possible the model calculations should be checked by third parties.



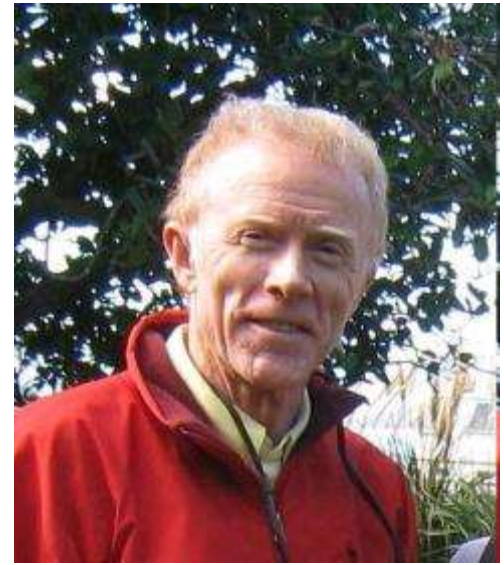
# RULE SIX: Do the right sums



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

# Expertise and responsibility

## Rule 6

- Most analyses offered as input to policy are framed as cost benefit analysis (monetization, the occupational psychosis of economists) or risk analyses



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.

# 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](http://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*

Andrea  
Saltelli

HOME ABOUT ME

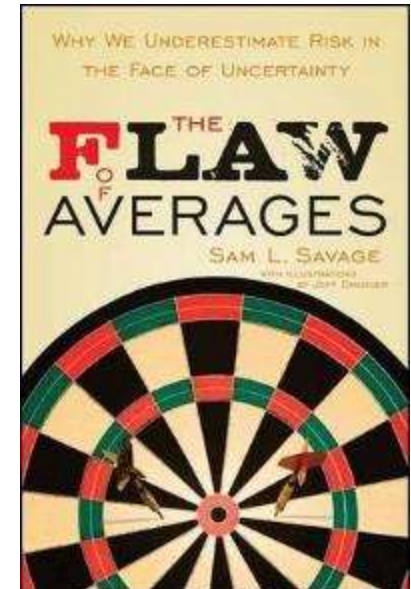
CAETERIS ARE  
NEVER PARIBUS

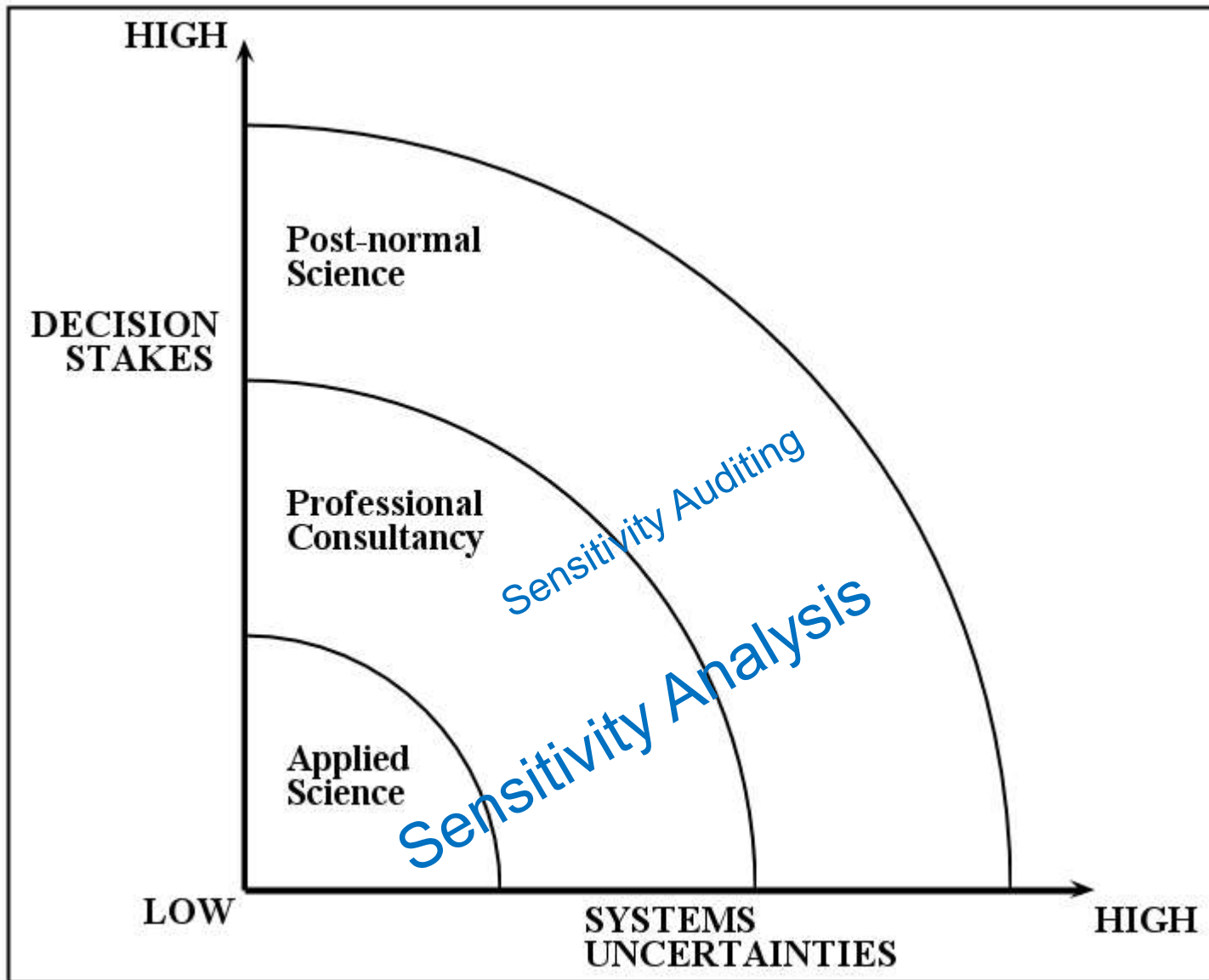
# RULE SEVEN: Explore diligently the space of the assumptions

How coupled ladders are shaken  
in most of available literature



How to shake coupled ladders





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

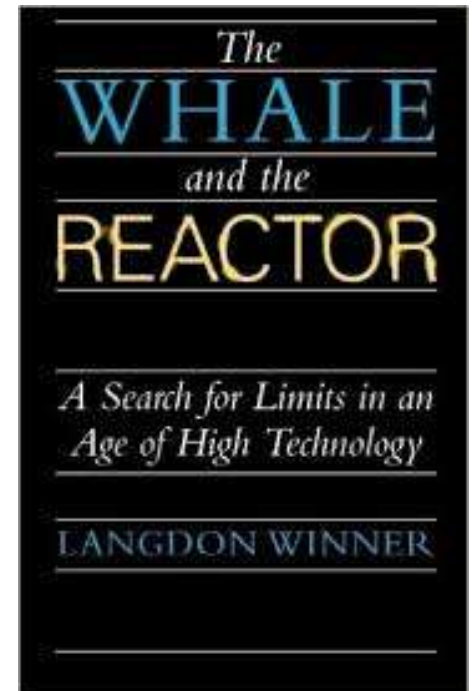
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ON NOT HITTING  
THE TAR-BABY

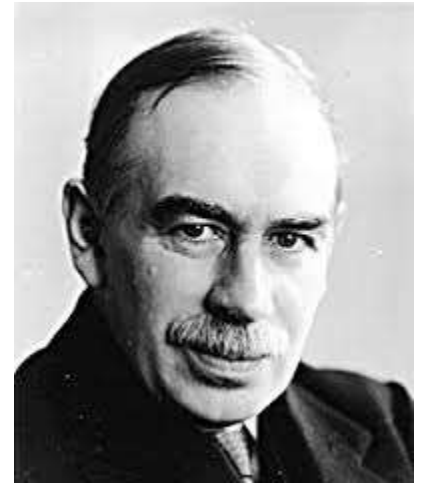
Winner, L., 1986. *The Whale and the Reactor: a Search for Limits in an Age of High Technology*. The University of Chicago Press, 1989 edition.



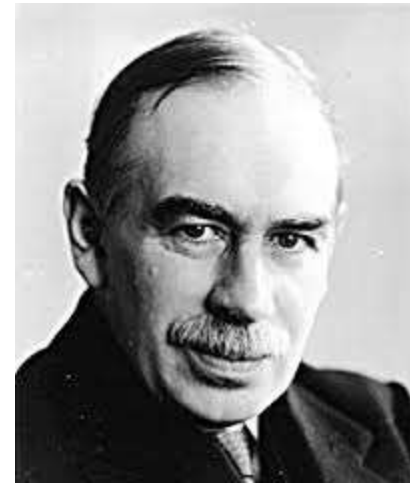
Langdon Winner



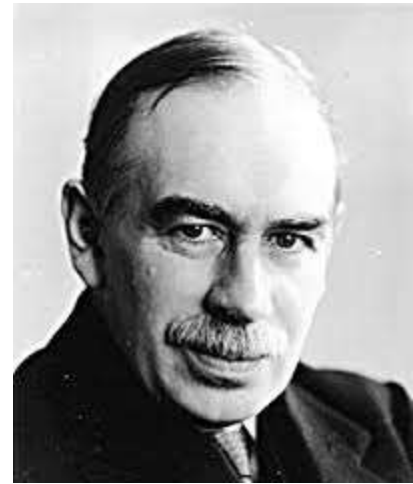
What does John Maynard Keynes say of cost benefit analysis in his 1936 work 'The General Theory of Employment, Interest, and Money'?



“If we speak frankly, we have to admit that our basis of knowledge for estimating the yield ten years hence of a railway, a copper mine, a textile factory, the goodwill of a patent medicine, an Atlantic liner, a building in the City of London amounts to little and sometimes to nothing; or even five years hence...”

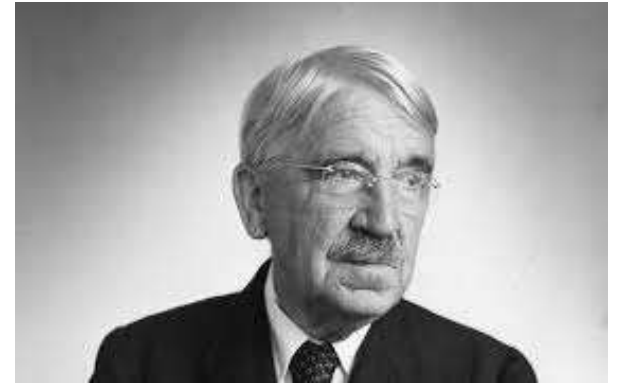


“... In fact, those who seriously attempt to make any such estimate are often so much in the minority that their behaviour does not govern the market.”



# Frames

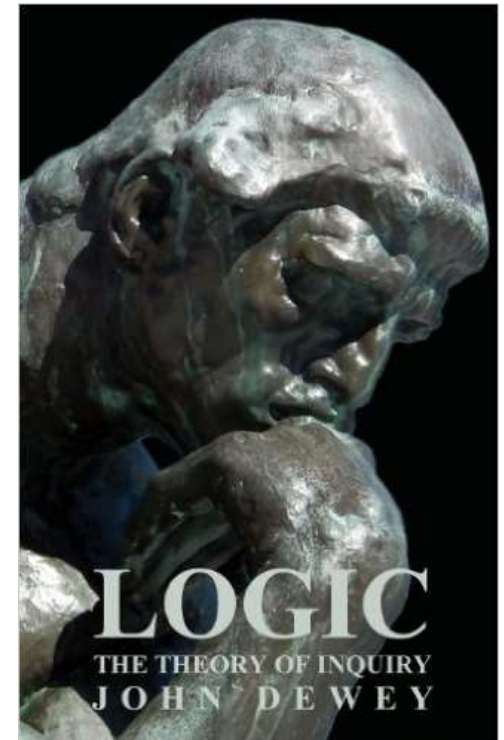
John Dewey suggested the concept of  
‘occupational psychosis’



John Dewey  
1859-1952

- ➔ Thus CBA = professional psychosis of economists
- ➔ Funtowicz and Ravetz’s Extended Peer Community because experts have ‘lenses’
- ➔ Feyerabend's intuition that citizens mature by learning about experts’ fallibility ...

John Dewey, *Logic: The Theory of Inquiry* (1938), Saerchinger Press (2007)

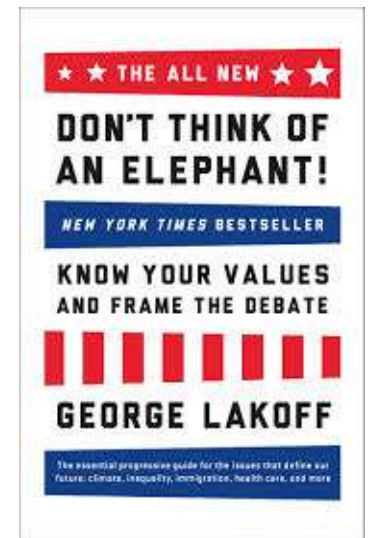


# Frames

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

Published road accident statistics record the conditions of the driver as to alcohol or drug use but not the make and year of the car or its safety features (Gusfield, 1981).



Gusfield, J. (1981). *The Culture of Public Problems. Drinking-Driving and the Symbolic Order.* The University of Chicago Press.

# Frames

“[...] genetically modified crops, declared safe by the scientific establishment, but reviled as Frankenfoods by the Subarus-and-sandals set”, ... (The Economist, 2014).



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

Which were the real concerns?

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?

## Why Free Markets Make Fools of Us

Cass R. Sunstein

OCTOBER 22, 2015 ISSUE

*Phishing for Phools: The Economics of Manipulation and Deception*

by George A. Akerlof and Robert J. Shiller  
Princeton University Press, 272 pp., \$24.95



*The Rolls-Royce Silver Cloud — \$13,595*

“At 60 miles an hour the loudest noise in this new Rolls-Royce comes from the electric clock”

*An advertisement for Rolls-Royce from the late 1950s*

# Frames

For Akerlof and Shiller - against what the ‘invisible hand’ would contend - economic actors have no choice but to exploit frames to ‘phish’ people into practices which benefit the actors not the subject phished.



George Akerlof



Robert R. Shiller

# 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

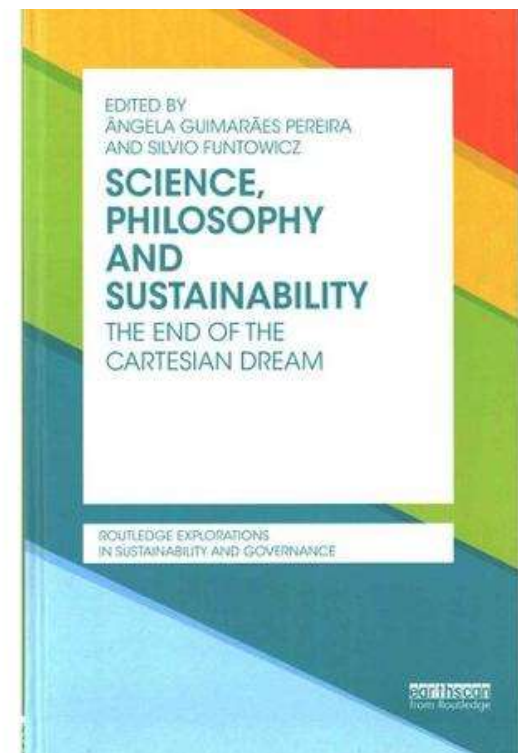
Ravetz, J., R., 1987, Usable Knowledge, Usable Ignorance, Incomplete Science with Policy Implications, *Knowledge: Creation, Diffusion, Utilization*, 9(1), 87-116.

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).

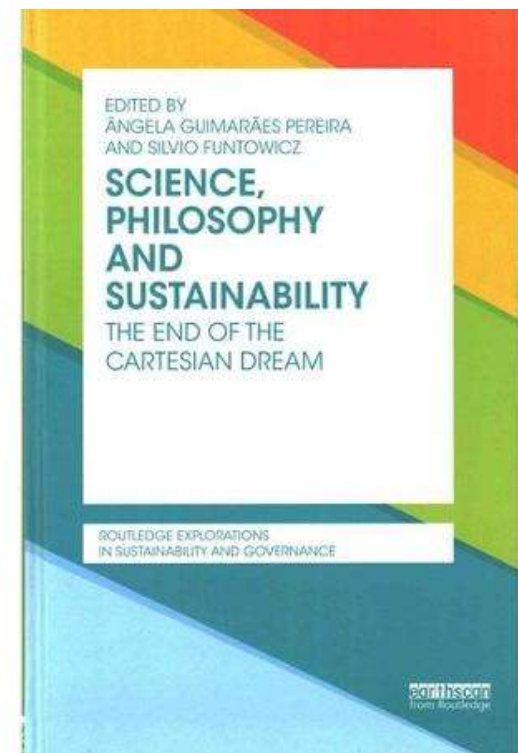
- A plea for a rediscovery of ignorance
  - especially ignorance generated by science itself;



Ravetz, J., R., 2015, Descartes and the rediscovery of ignorance, in Guimarães Pereira, Â., and Funtowicz, S., Eds., 2015, The end of the Cartesian dream, Routledge's series: Explorations in Sustainability and Governance.

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

- Dichotomy between knowledge and ignorance as problematic as that between facts and value;
- Ignorance useful: work can be done on its boundaries (finding where these can be penetrated, spotting signals of troubles ahead).



Ravetz, J., R., 2015, Descartes and the rediscovery of ignorance, in Guimarães Pereira, Â., and Funtowicz, S., Eds., 2015, The end of the Cartesian dream, Routledge's series: Explorations in Sustainability and Governance.

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

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

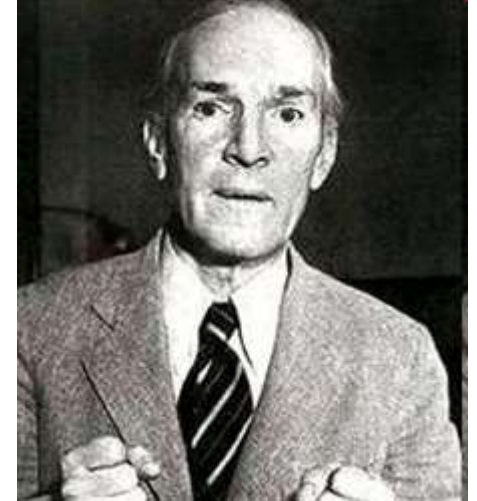
The larger the “uncomfortable knowledge” an institution needs to maintain, the closer it is to its ancient régime stage (Funtowicz and Ravetz, 1994).

Funtowicz, S.O. and Jerome R. Ravetz, 1994, Emergent complex systems, *Futures*, 26(6), 568–582.



## Why frames ‘stick’

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



Upton Sinclair

## Discussion point



- Can I recall an example of uncomfortable knowledge?

## Discussion points



- Can I recall an example of a framing which did not sound right to me?

# So what does quantitative story telling propose?

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



Mario Giampietro

Andrea Saltelli and Mario Giampietro, 2017, What is wrong with evidence based policy, and how can it be improved? Forthcoming on FUTURES,  
[http://www.andreasaltelli.eu/file/repository/FUTURES\\_Saltelli\\_Giampietro\\_6.pdf](http://www.andreasaltelli.eu/file/repository/FUTURES_Saltelli_Giampietro_6.pdf)



Instead of Evidence-based policy: robust policy.

Test for:

- feasibility (compatibility with processes outside human control);
- viability (compatibility with processes under human control, in relation to both the economic and technical dimensions); and
- desirability (compatibility with a multitude of normative considerations relevant to a plurality of actors).

Techno-science is at the heart of contemporary narratives supporting ways to:

- innovate our way out of the economic crisis;
- overcome our planetary boundaries;
- achieve a dematerialized / circular / decarbonized economy;

Quantitative story telling is used in the project Magic-Nexus to test the quality of these and others narratives.



# 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



[http://www.andreasaltelli.eu/file/repository/Decalogue\\_of\\_the\\_diligent\\_quantifier\\_online\\_Version\\_2.pdf](http://www.andreasaltelli.eu/file/repository/Decalogue_of_the_diligent_quantifier_online_Version_2.pdf)



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