

# Sensitivity Auditing

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Training for Directorate C, EPRS  
Brussels

19–20 November 2015

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# 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/>

www.andreasaltelli.eu

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Presentations

Welcome to the home page of Andrea Saltelli

*Caeteris are never paribus*

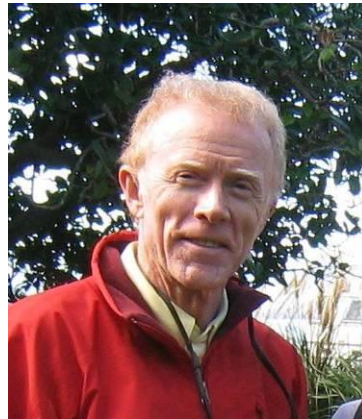
Where to find materials

andrea.saltelli@uib.no

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

# Sensitivity analysis

When testing the evidence behind inference some reasonable people (and guidelines) suggest that ‘sensitivity analysis would help’



...

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



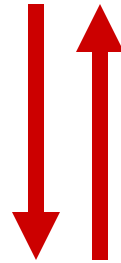
<<I have proposed a form of organised sensitivity analysis that I call “global sensitivity analysis” in which a neighborhood of alternative assumptions is selected and the corresponding interval of inferences is identified.>>

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



<<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.>>

**Funtowicz & Ravetz's** GIGO (Garbage In, Garbage Out) Science – 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’.

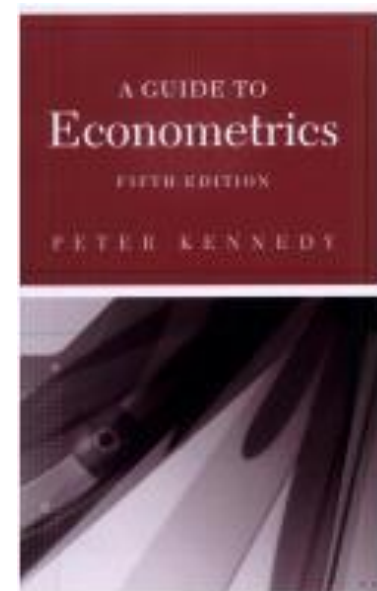
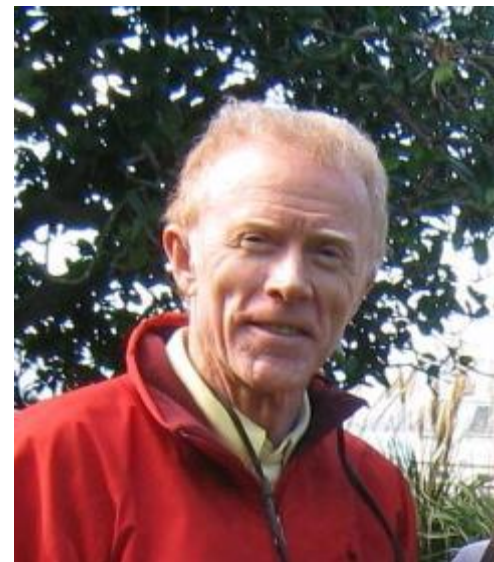


Peter Kennedy, A Guide to Econometrics.

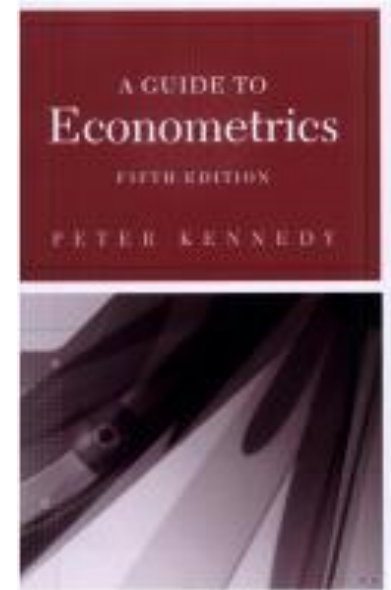
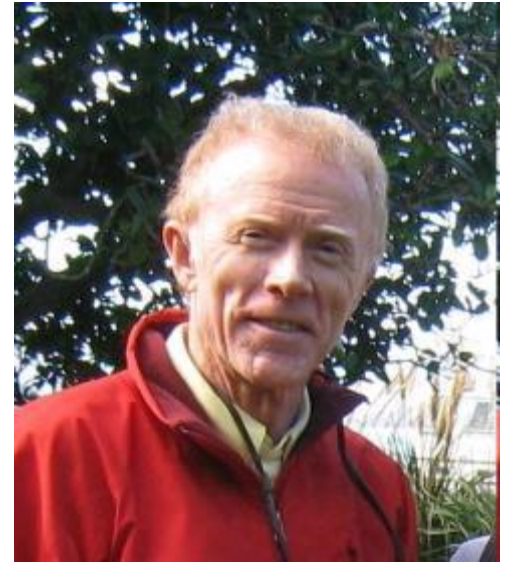
Anticipating criticism by applying sensitivity analysis. This is one of the ten commandments of applied econometrics according to Peter Kennedy:

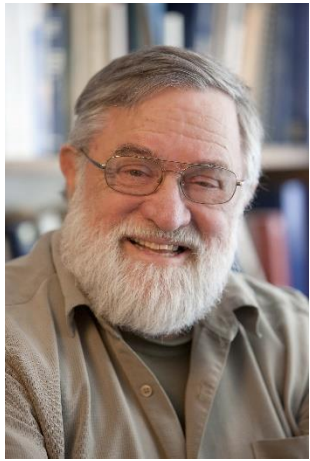
<<Thou shall confess in the presence of sensitivity.

Corollary: Thou shall anticipate criticism >>



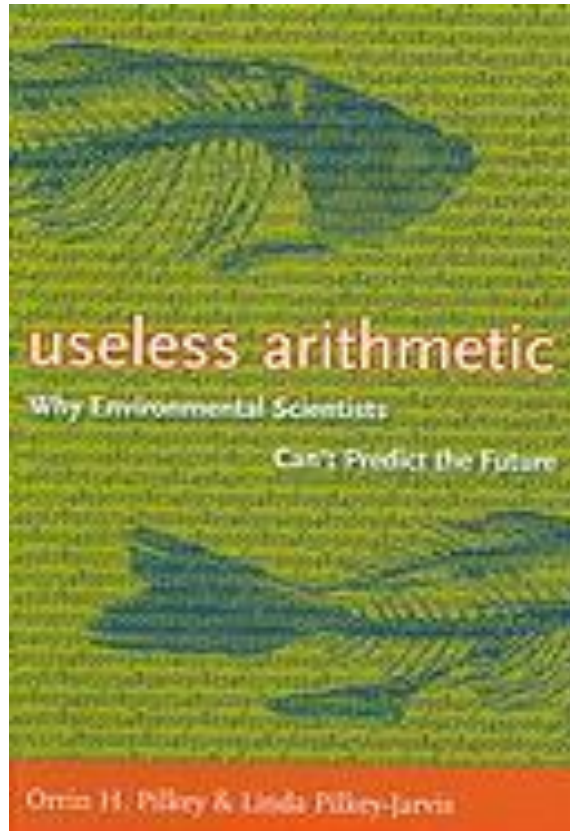
<<When reporting a sensitivity analysis, researchers should explain fully their specification search so that the readers can judge for themselves how the results may have been affected. This is basically an 'honesty is the best policy' approach, [...]'>>



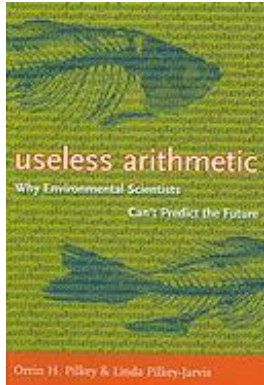


Orrin H. Pilkey  
Duke University,  
NC

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



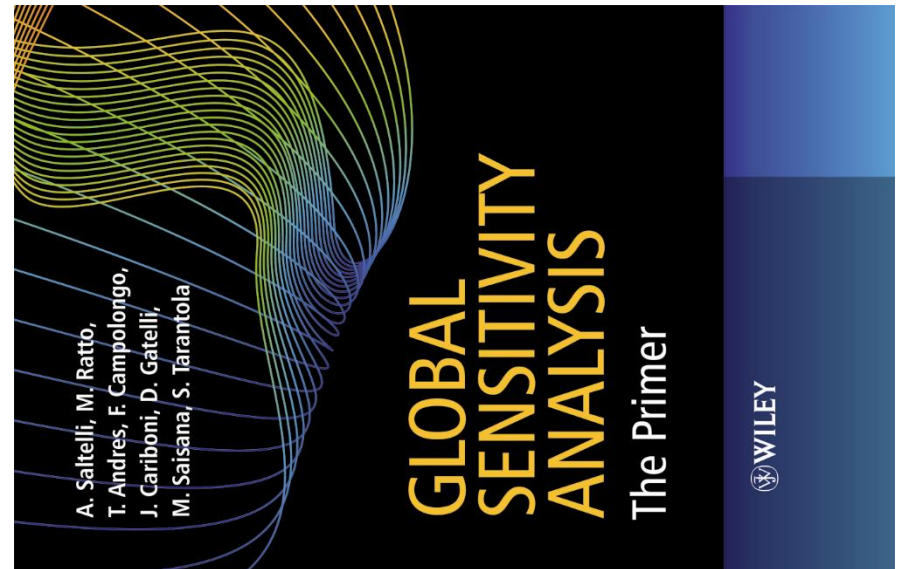
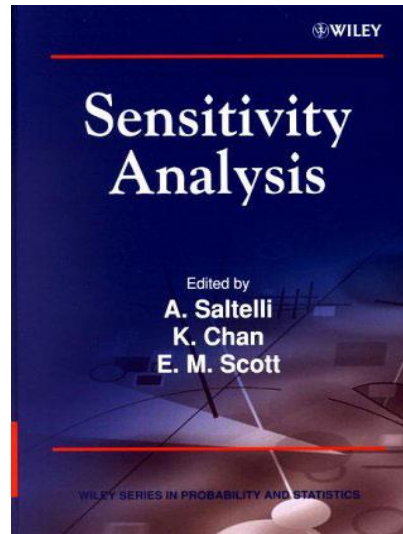
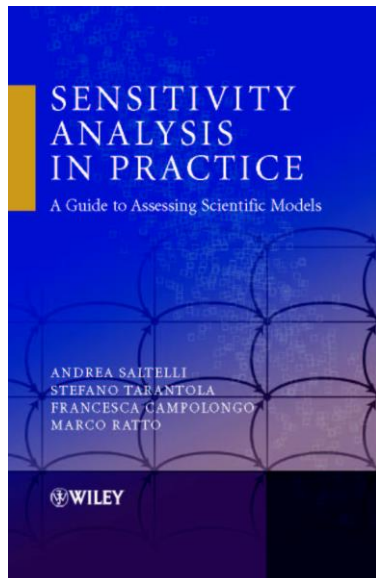
‘Quantitative mathematical models used by policy makers and government administrators to form environmental policies are seriously flawed’



<<It is important, however, to recognize that the sensitivity of the parameter in the equation is what is being determined, not the sensitivity of the parameter in nature.

[...] If the model is wrong or if it is a poor representation of reality, determining the sensitivity of an individual parameter in the model is a meaningless pursuit.>>

# Books

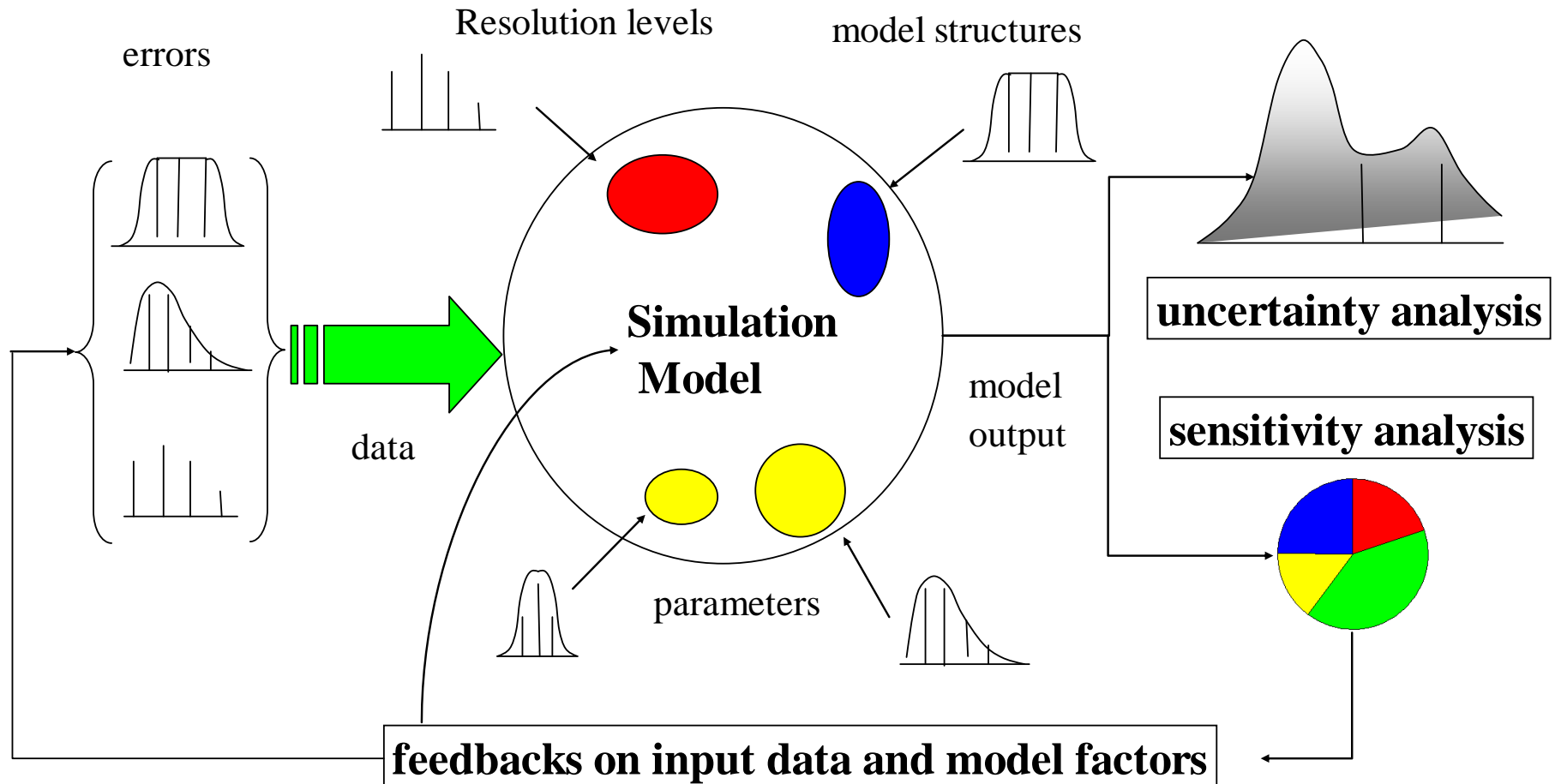




[Global\*] sensitivity analysis: “The study of how the uncertainty in the output of a model (numerical or otherwise) can be apportioned to different sources of uncertainty in the model input”

Saltelli A., 2002, Sensitivity Analysis for Importance Assessment, Risk Analysis, 22 (3), 1–12.

# An engineer's vision of UA, SA



# Sensitivity auditing





## Better Regulation

European  
Commission

European Commission > Better Regulation

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- Roadmaps / Inception Impact Assessments
- Impact Assessment
- Evaluation
- Regulatory Scrutiny Board
- Guidelines
- Key documents

### Better regulation

Better regulation is about designing EU policies and laws so that they achieve their objectives at minimum cost. It ensures that policy is prepared, implemented and reviewed in an open, transparent manner, informed by the best available evidence and backed up by involving stakeholders.

To ensure that EU action is effective, the Commission assesses the expected and actual impacts of policies, legislation and other important measures at every stage of the policy cycle - from planning to implementation, to review and subsequent revision.

The [Commission decided on 19 Mar 2015](#) (172 kB) to create a REFIT Platform to advise the Commission on simplifying and making EU laws more effective and efficient.

The Commission publishes regularly [provisional dates of adoption of Commission initiatives](#).

#### Before the EU takes action

- The Commission publishes [roadmaps and inception impact assessments](#) describing planned new initiatives and evaluations of existing legislation.
- Commission [impact assessments](#) examine the potential economic, social and environmental consequences of proposed options for action.

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# Better Regulation

European Commission

European Commission > Better Regulation > Guidelines

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- Impact Assessment
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- Regulatory Scrutiny Board
- Guidelines**
  - Better Regulation Guidelines
  - Better Regulation "Toolbox"
- Key documents

## Better Regulation Guidelines






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


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

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




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


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

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What were you looking for?

# RULE ONE: Check against rhetorical use of mathematical modelling

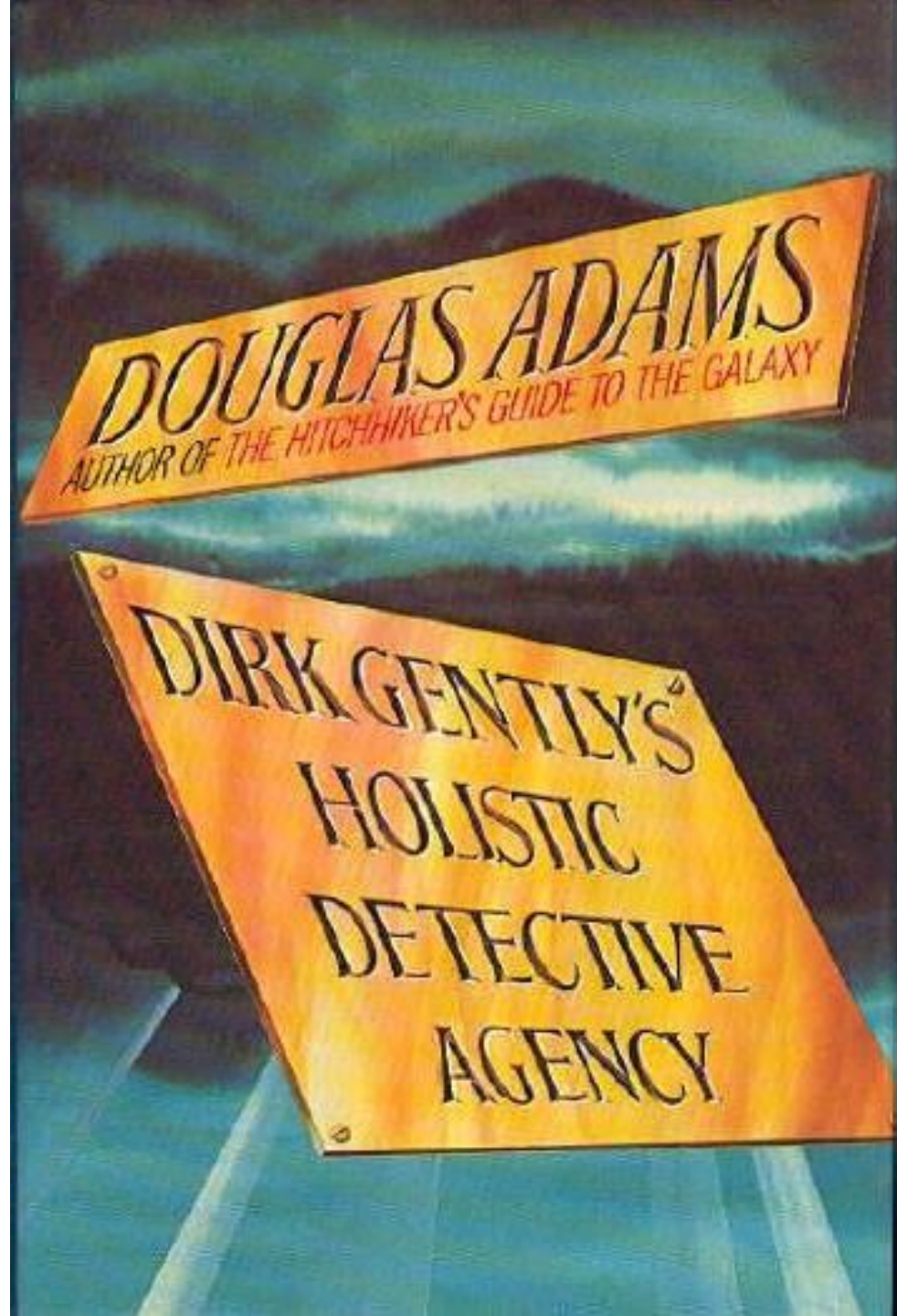


The instrumental use of mathematical modelling to advance one's agenda can be termed rhetorical, or strategic, like the use of Latin by the elites and the clergy in the classic age.





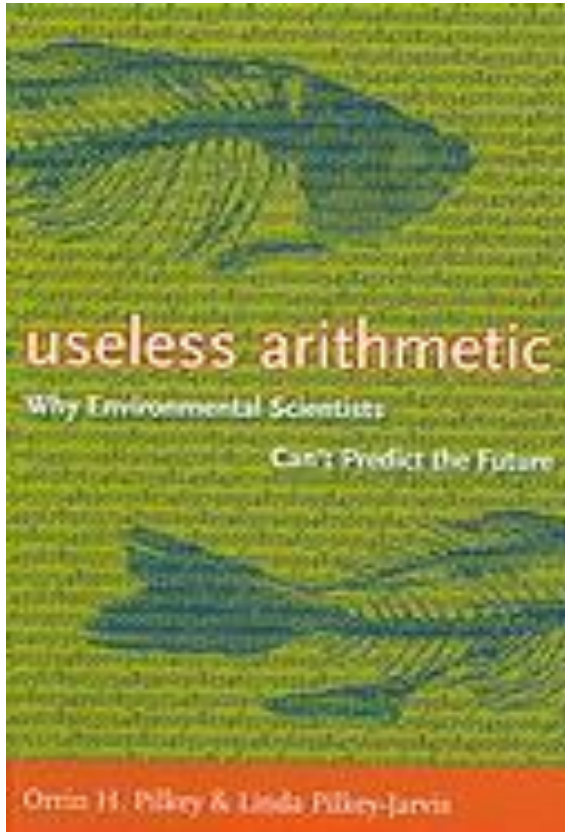
Pocket Books 1987, p.69



## 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 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’

# RULE ONE: Check against rhetorical use of mathematical modelling

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).



## 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





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



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

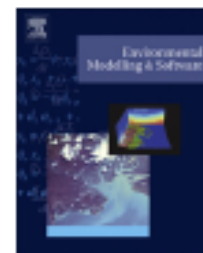
Erik Laes<sup>a,\*</sup>, Gaston Meskens<sup>b</sup>, Jeroen P. van der Sluijs<sup>c</sup>



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’ ...

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



# 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)



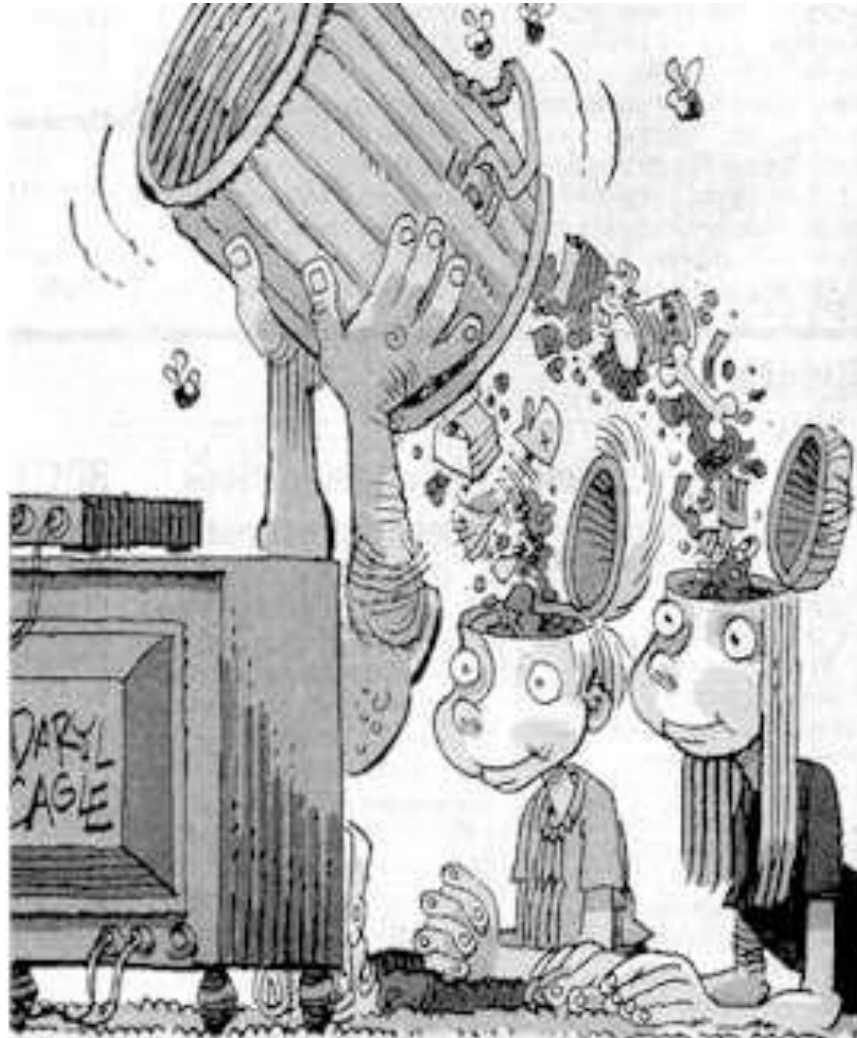
[...] knowledge regarding flooding was **co-produced**. This illustrates a way of working with experts, both **certified** (academic natural and social scientists) and **noncertified** (local people affected by flooding), [...] We reveal a **deep and distributed understanding** of flood hydrology across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

# 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;

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).

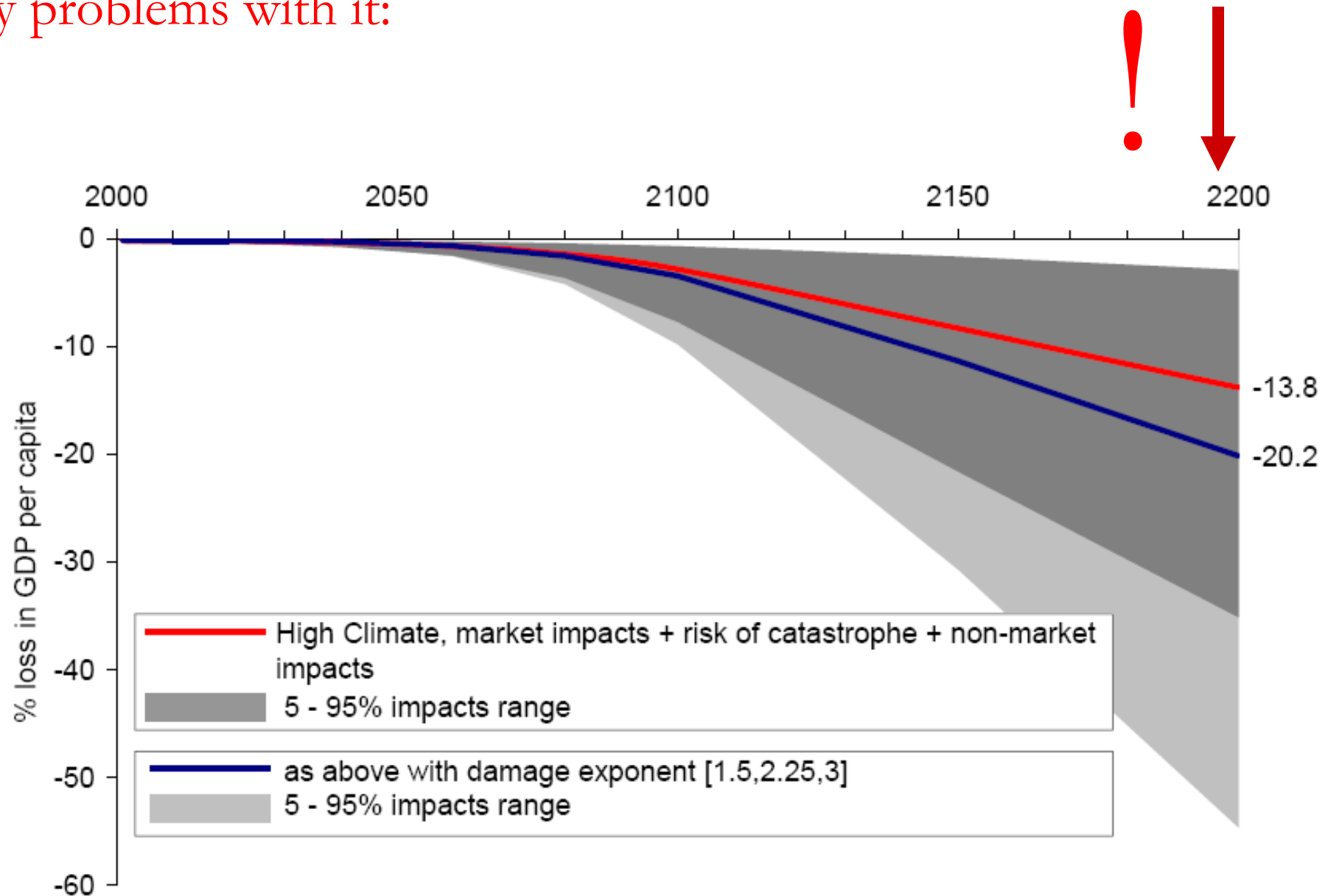
RULE FOUR: find sensitivities before sensitivities find you;

The Stern - Nordhaus exchange on *SCIENCE*

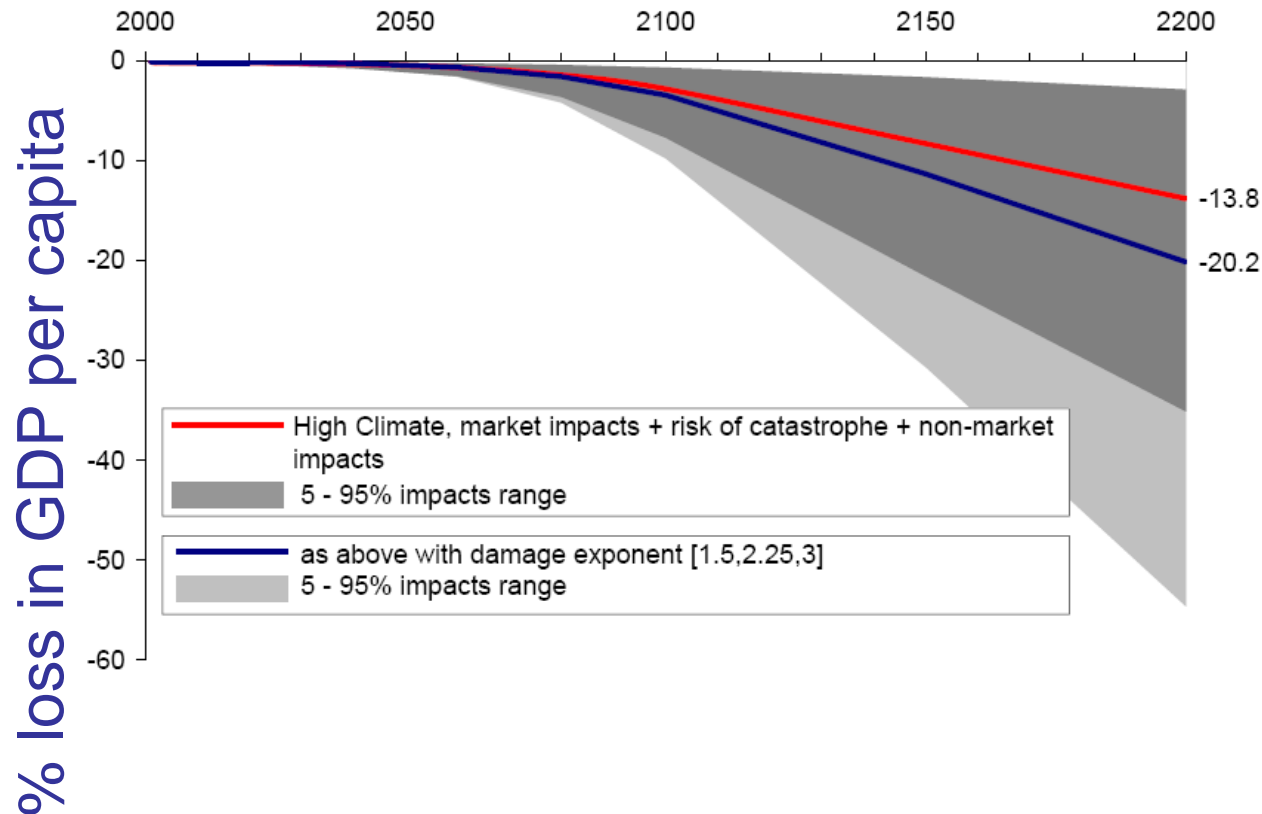
- 1) Nordhaus falsifies Stern based on 'wrong' range of discount rate
- 2) Stern's complements its review with a postscript: a sensitivity analysis of the cost benefit analysis
- 3) Stern infers: My analysis shows robustness'



My problems with it:



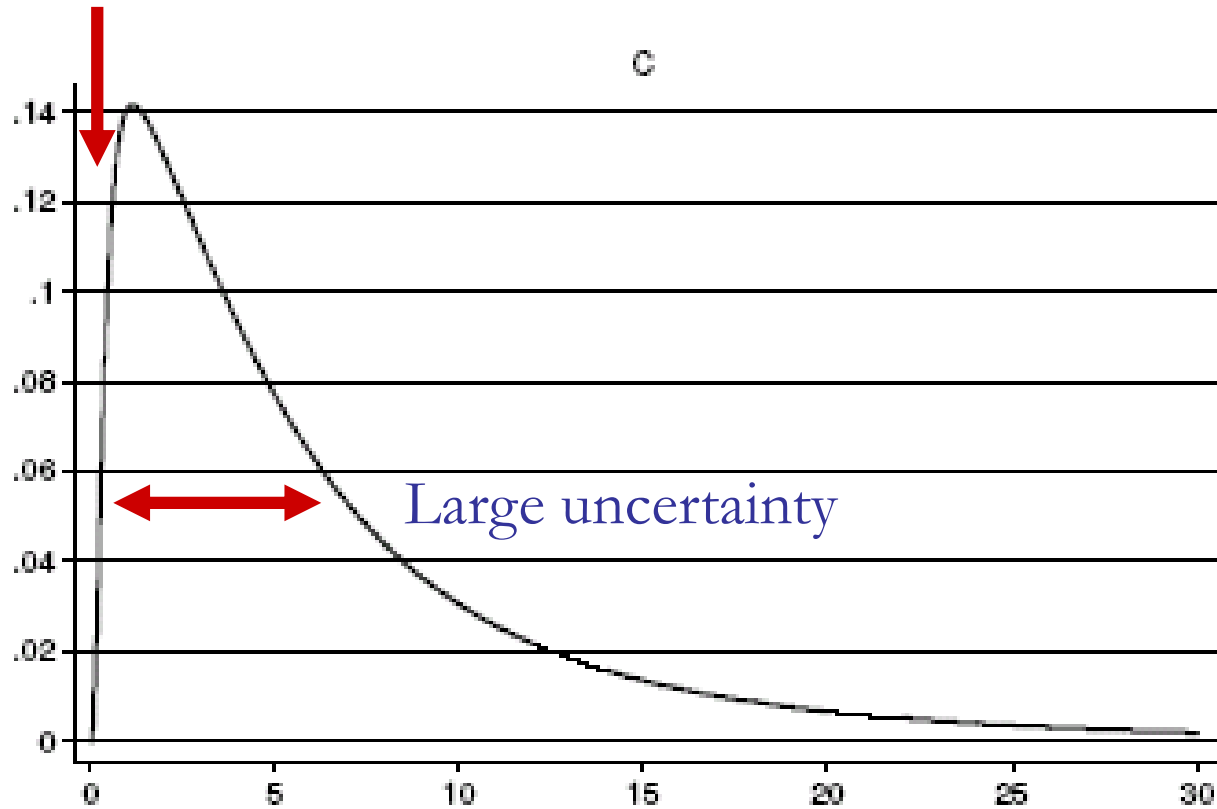
... but foremost Stern says:  
changing assumptions → important effect  
when instead he should admit that:  
changing assumptions → all changes a lot





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

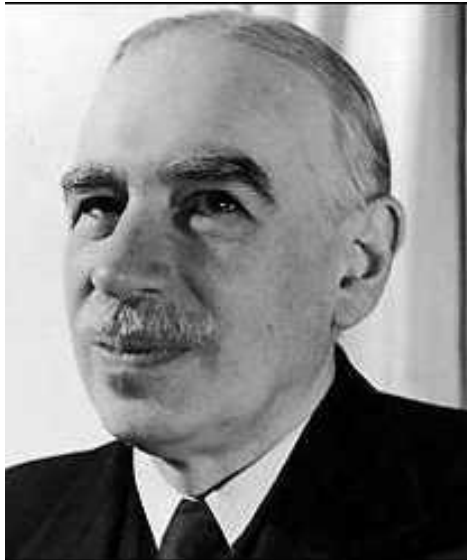
Missing points



% loss in GDP per capita

RULE FOUR: find sensitivities before sensitivities find you;

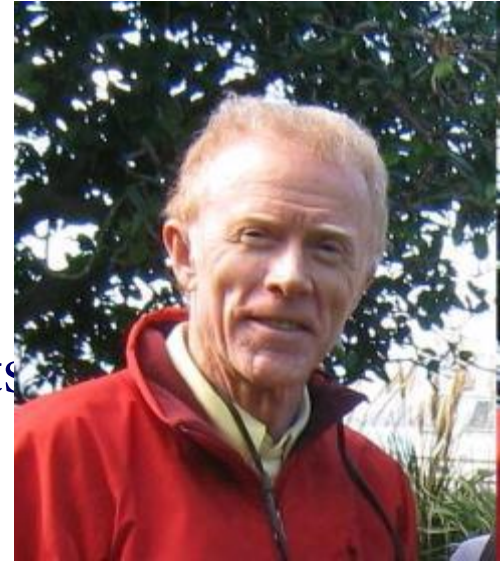
Same criticism applies to Nordhaus – both authors frame the debate around numbers which are ...



... precisely wrong

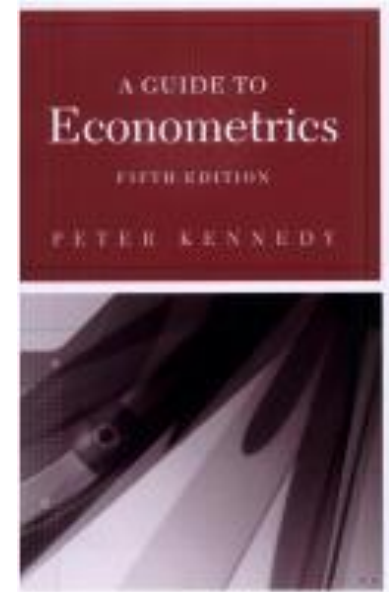
RULE FOUR: find sensitivities before sensitivities find you;

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

**Host of questions/ from advisers**  
**Economic model lacks transparency**

By Philip Clark in London

The credibility of a European energy review has been cast into doubt by opposition advisers who say plans to cut carbon emissions up to 50% are based on an economic model created by a single Greek university that cannot be independently verified.

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 Primos, is owned by the National Technical University of Athens and is designed to show how the use of different groups of energy sources affect the wider economy.

The European Commission has used it for 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 trade group, IndustriEurope, has asked for the Commission to use other, more transparent models.

The forecasting section of the energy road map, which will review the effect of changing sun, more wind and the 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 Primos model to produce different energy mix scenarios for the road map.

"There was considerable debate about the role of the oil fuel price assumption in the Primos model," said the report by the group, which is chaired by Dieter Helm, an Oxford university economics professor, and



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

included bodies such as the International Energy Agency.

There were also questions on "the costs of different technologies" and "the assumption of perfect flexibility by companies but not by individuals".

The groups key concern was "what the transparency of the Primos work, and in particular the private rights in the algo-

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

ritms and detailed internal workings of the model", says the report, which is leaked "this data".

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

The consequence is that independent parties cannot verify the results. This is a substantial barrier for the Commission, not least

if the review turned out that it does have serious consequences for the credibility of the road map."

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

Parsons Dapag, an adviser from the National Technical University of Athens who built the Primos model, told the Financial Times he agreed that transparency was important and would not mind if some of the model's workings were made public, "but not the whole deal - not the software".

A spokeswoman for the energy commissioner, Günther Oettinger, said she would 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.

Prof Capoen has been an energy consultant for many years and has held positions as bodies ranging from Geneva's energy regulator to the country's Public Power Corporation.

## 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.”

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## Part IX

# Office of Management and Budget

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**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/infoereg/>



## 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

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



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.”

113TH CONGRESS  
2D SESSION

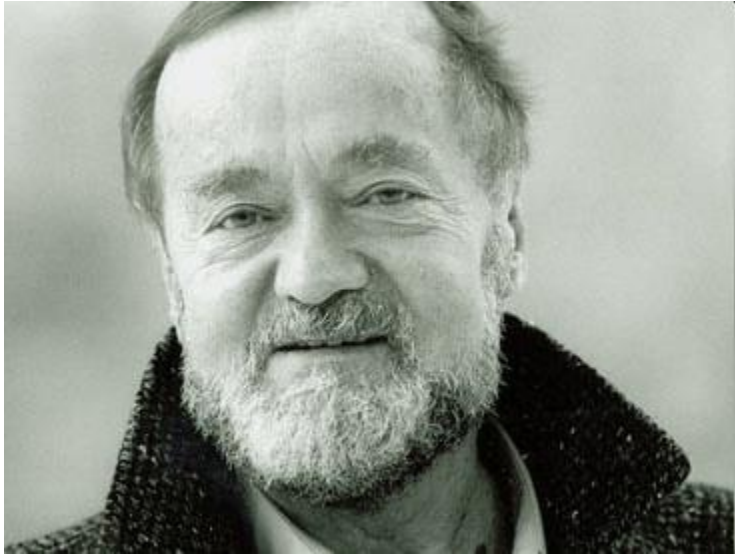
# H. R. 4012

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 SIX: Do the right sums



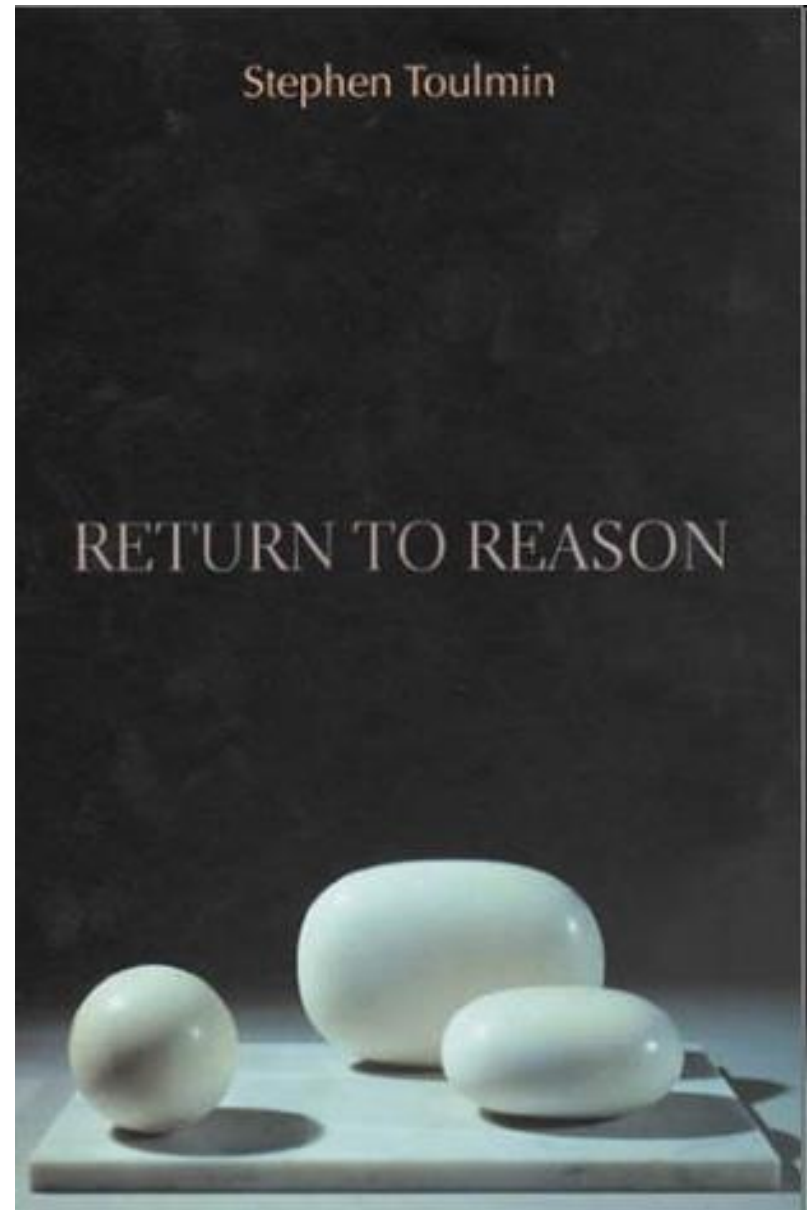
Do the sum right

Versus

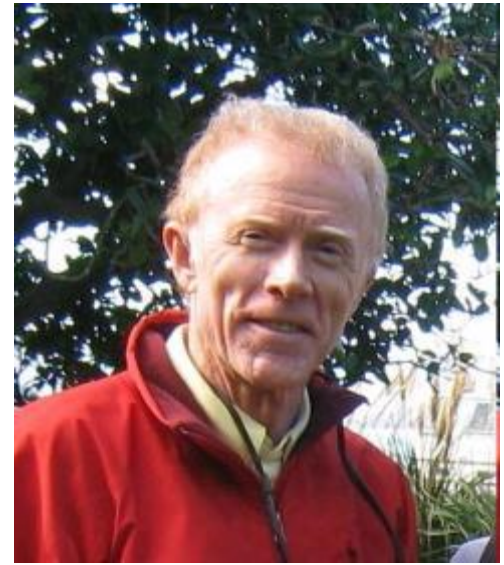
Do the right sums

(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



- Experts as stakeholders among many, with their occupational psychoses.
- Example: most analyses offered as input to policy are framed as cost benefit analysis (monetization, the occupational psychosis of economists) or risk analyses.
- Techniques (such as CBA) is never neutral; according to Winner (1986) ecologists should not fall into the trap of CBA.



Langdon Winner

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

# Frames

- Contrary to the popular belief that climate sceptics don't know about climate science Dan Kahan (2014) has observed that the more a person is informed about climate science, the more he or she is likely to be polarized on the issue in either direction.

# Frames

- Contrary to the popular belief that a GMO-averse person is a risk- or technology-averse individual, an important EC study (Marris, 2001) has shown that GMO aversion is linked to frames where risk plays a very minimal role (and alimentary risk plays no role at all).

# 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).

# 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.



The issue of frames. How do we perceive the world. Socially constructed ignorance etc.

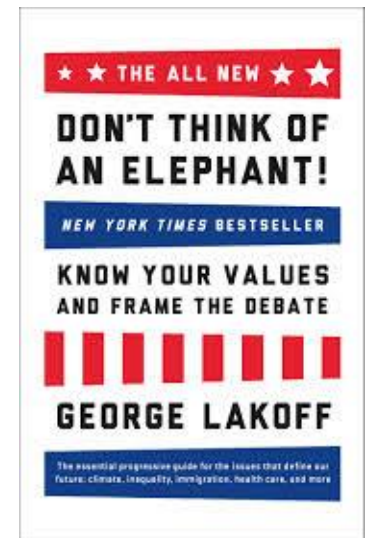
Lakoff, G., 2010, Why it Matters How We Frame the Environment, Environmental Communication: A Journal of Nature and Culture, 4:1, 70-81.

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

For a summary see [http://www.andreasaltelli.eu/file/repository/Hypocognition\\_Etc.pdf](http://www.andreasaltelli.eu/file/repository/Hypocognition_Etc.pdf)



George Lakoff



## Questions about GMO deemed relevant by citizens (Marris, 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?



Frames; GMO presented as a food scare.

“Montpelier is **America’s only McDonald’s-free state capital**. A fitting place, then, for a law designed to satisfy the unfounded fears of foodies [...] 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

# Why Free Markets Make Fools of Us

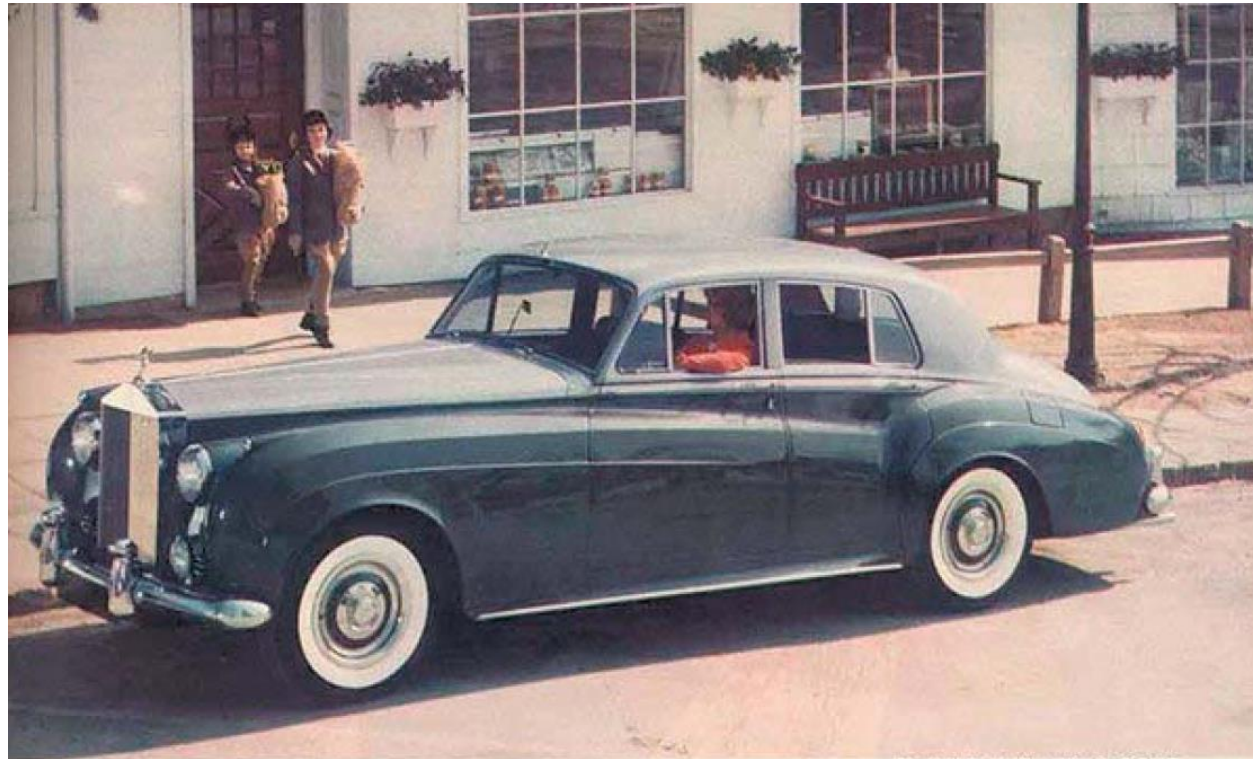
Cass R. Sunstein

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 — \$13,995*

“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 and narratives

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

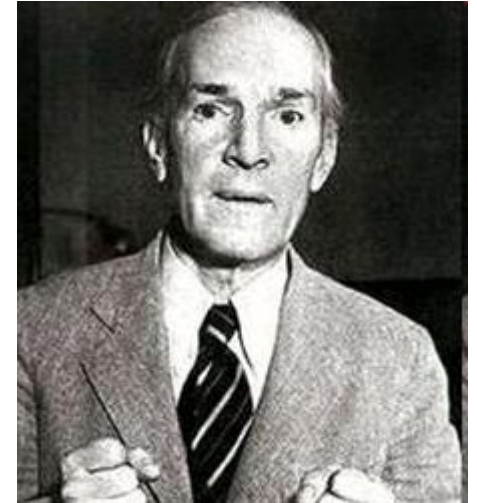


Robert R. Shiller



## On the persistence of narratives

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



Upton Sinclair



# RULE SEVEN: Explore diligently the space of the assumptions

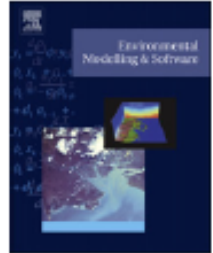
Environmental Modelling & Software 25 (2010) 1508–1517



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## How to avoid a perfunctory sensitivity analysis

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# RULE SEVEN: Explore diligently the space of the assumptions

How coupled ladders are shaken  
in most of available literature



How to shake coupled ladders

