

Sensitivy auditing

Andrea Saltelli

Centre for the Study of the Sciences and
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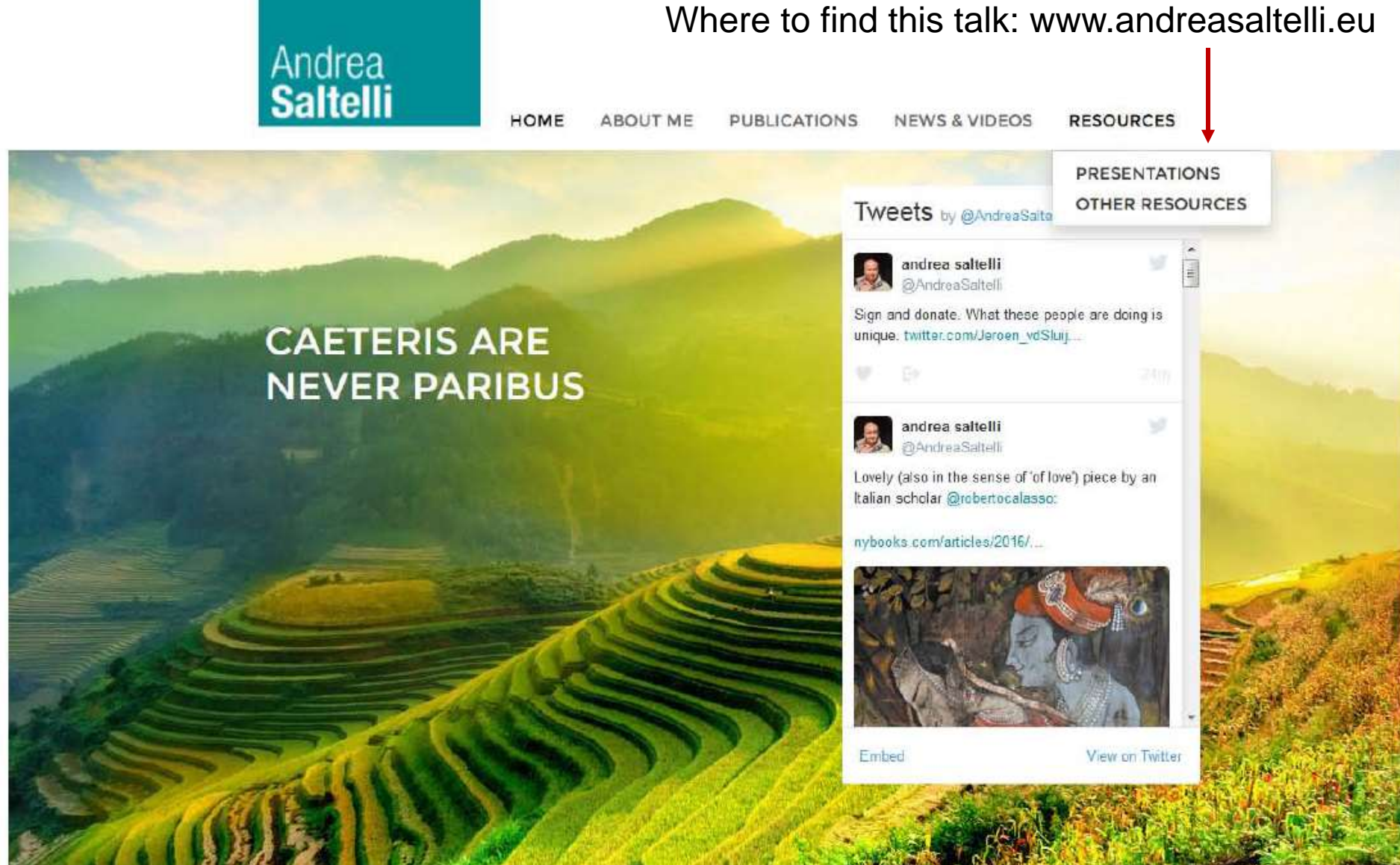
& visiting fellow at Open Evidence
Research, Universitat Oberta de Catalunya
(UOC), Barcelona

Workshop on critical appraisal of
knowledge in environmental assessments

28 May 2018

European Environment Agency, Kongens
Nytorv 6, 1400, Copenhagen

Where to find this talk: www.andreasaltelli.eu



The screenshot shows the homepage of the website www.andreasaltelli.eu. The header features the name "Andrea Saltelli" in a teal box on the left and a navigation menu on the right with links: HOME, ABOUT ME, PUBLICATIONS, NEWS & VIDEOS, and RESOURCES. A red arrow points from the URL above to the "RESOURCES" link. Below the navigation menu, a dropdown menu is open, showing "PRESENTATIONS" and "OTHER RESOURCES". The main content area has a large background image of terraced rice fields with the text "CAETERIS ARE NEVER PARIBUS" overlaid. On the right side, there is a "Tweets by @AndreaSaltelli" widget displaying two tweets. The first tweet says "Sign and donate. What these people are doing is unique." with a link to a Twitter profile. The second tweet says "Lovely (also in the sense of 'of love') piece by an Italian scholar" with a link to a book review. Below the tweets are links for "Embed" and "View on Twitter".

Andrea Saltelli

HOME ABOUT ME PUBLICATIONS NEWS & VIDEOS RESOURCES

PRESENTATIONS OTHER RESOURCES

CAETERIS ARE NEVER PARIBUS

Tweets by @AndreaSaltelli

andrea saltelli @AndreaSaltelli
Sign and donate. What these people are doing is unique. twitter.com/Jeroen_vdSluisj...

andrea saltelli @AndreaSaltelli
Lovely (also in the sense of 'of love') piece by an Italian scholar [@robertocalasso: nybooks.com/articles/2016/...](https://robertocalasso.nybooks.com/articles/2016/...)

Embed View on Twitter

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



= more material on
www.andreasaltelli.eu

Training “Numbers for Policy”, Barcelona

August 27th – September 1st

<http://www.uib.no/en/svt/115575/numbers-policy-practical-problems-quantification>



UNIVERSITY OF BERGEN



Sensitivity analysis

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



Sensitivity auditing

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

Quantitative storytelling

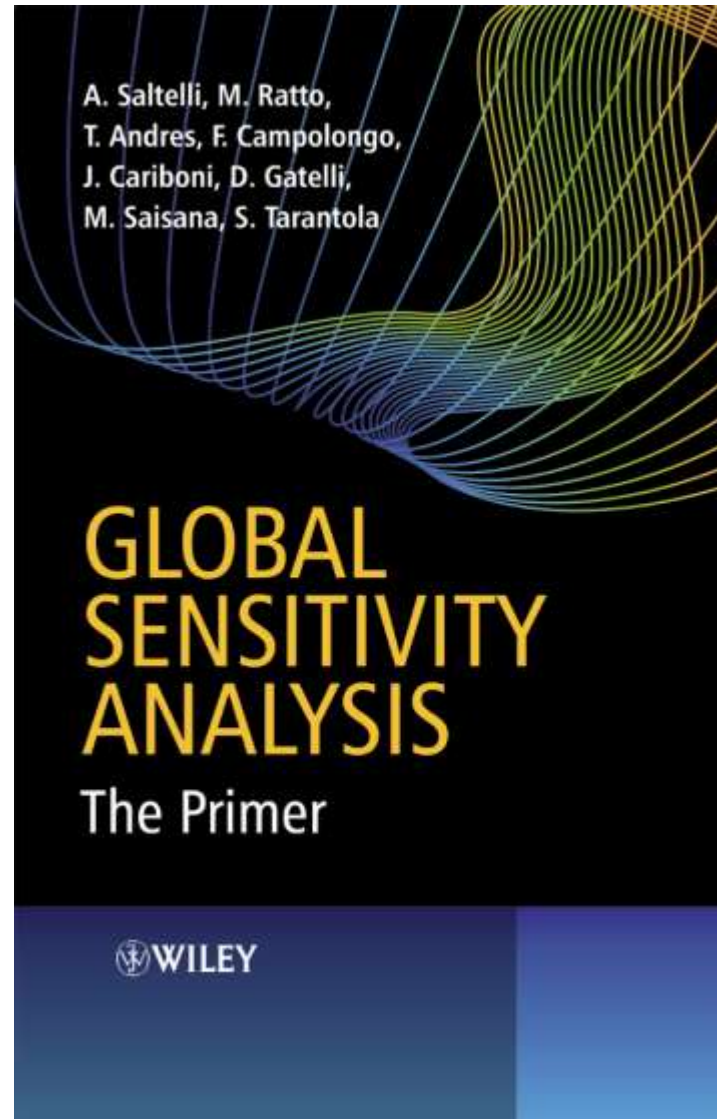
[Saltelli, A., Giampietro, M., 2017, What is wrong with evidence based policy, and how can it be improved? Futures, 91, 62-71.](#)

A new grammar

[Saltelli, A., Does Modelling need a reformation? Ideas for a new grammar of modelling, on ArXiv](#)

Sensitivity analysis

Sensitivity analysis book available on LibGen



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



Source: IA Toolbox, p. 391



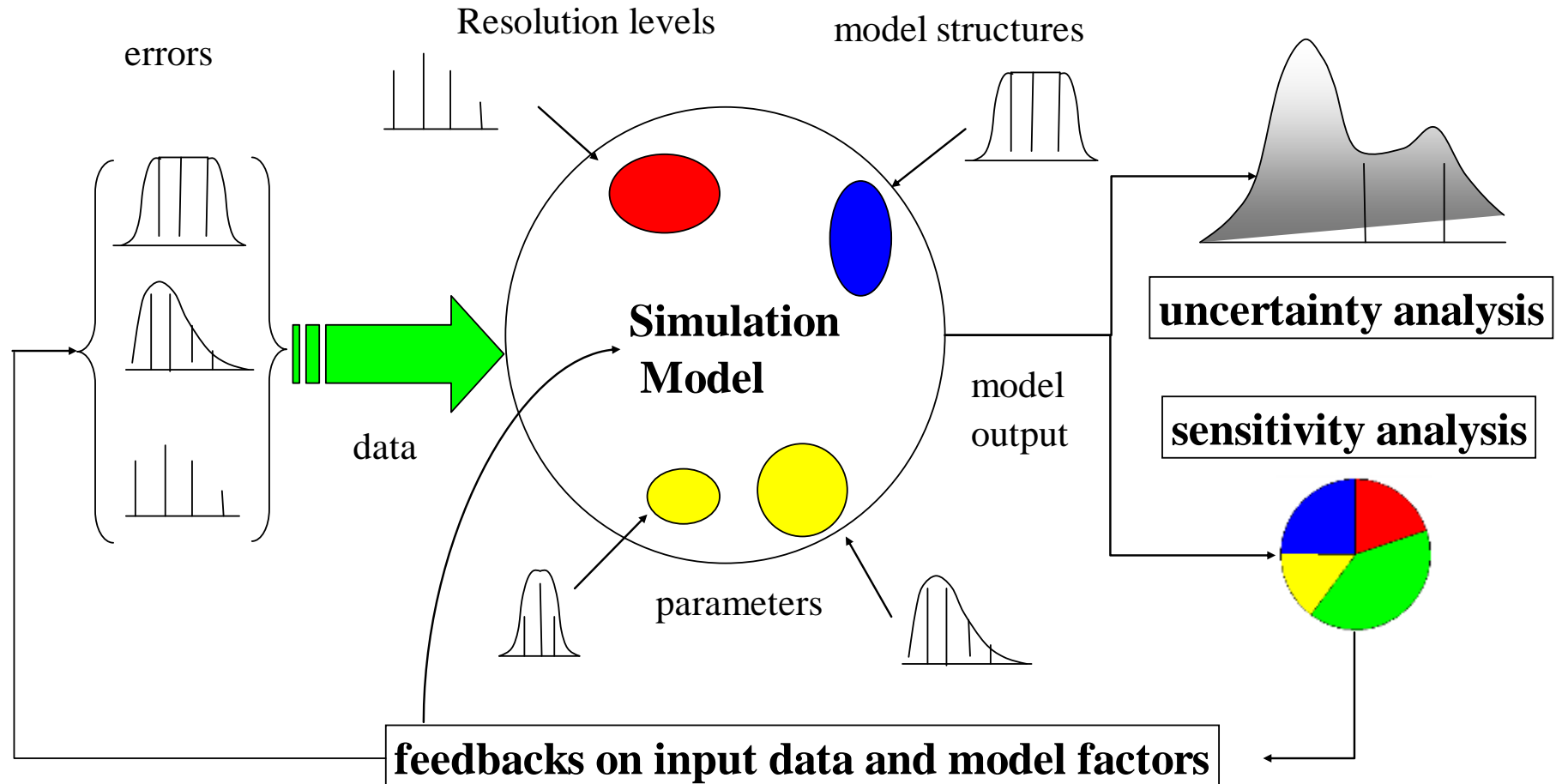
4. SENSITIVITY AND UNCERTAINTY ANALYSES

Page 391

Six steps for a global SA:

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

An engineer's vision of UA, SA

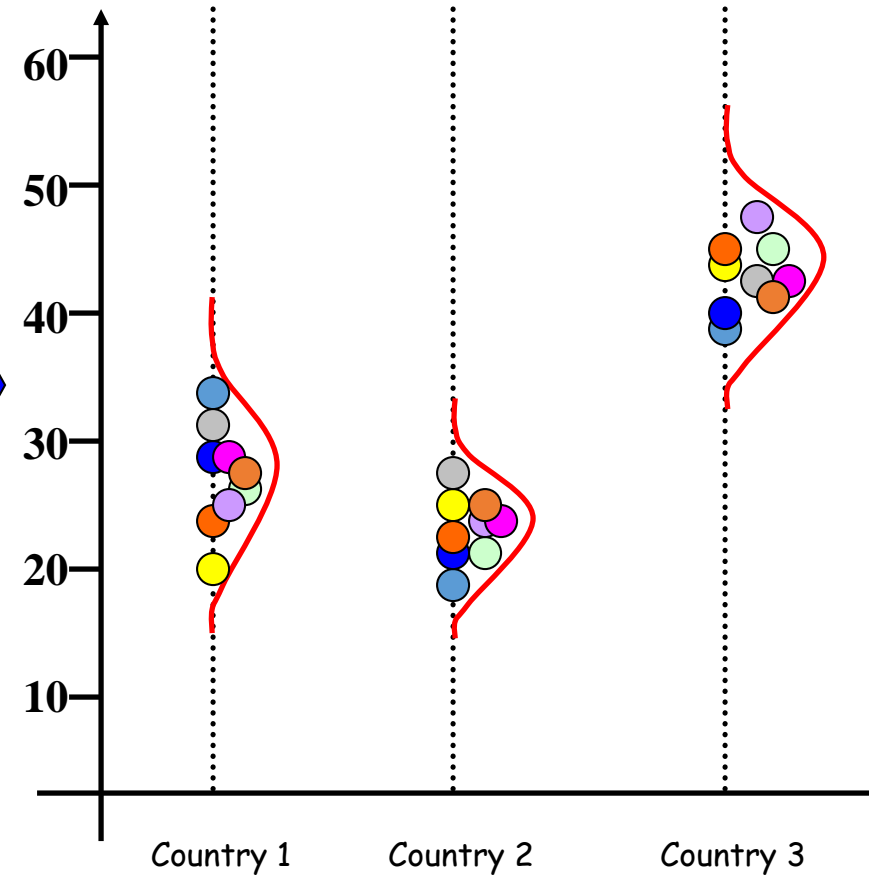
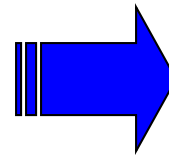
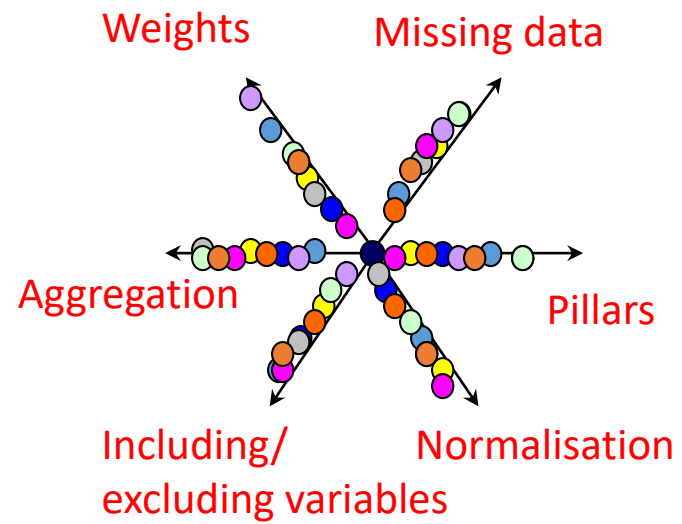


One can sample more than just factors

One can sample modelling
assumptions, alternative data sets,
resolution levels...

Assumption	Alternatives
Number of indicators	<ul style="list-style-type: none">▪ all six indicators included or one-at-time excluded (6 options)
Weighting method	<ul style="list-style-type: none">▪ original set of weights,▪ factor analysis,▪ equal weighting,▪ data envelopment analysis
Aggregation rule	<ul style="list-style-type: none">▪ additive,▪ multiplicative,▪ Borda multi-criterion

Space of alternatives



Why should one
ever run a model
just once?

Sensitivity auditing

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



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

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.

The rules of sensitivity auditing

Rule 1: Check against rhetorical use of mathematical modelling;

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

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

The rules of sensitivity auditing

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

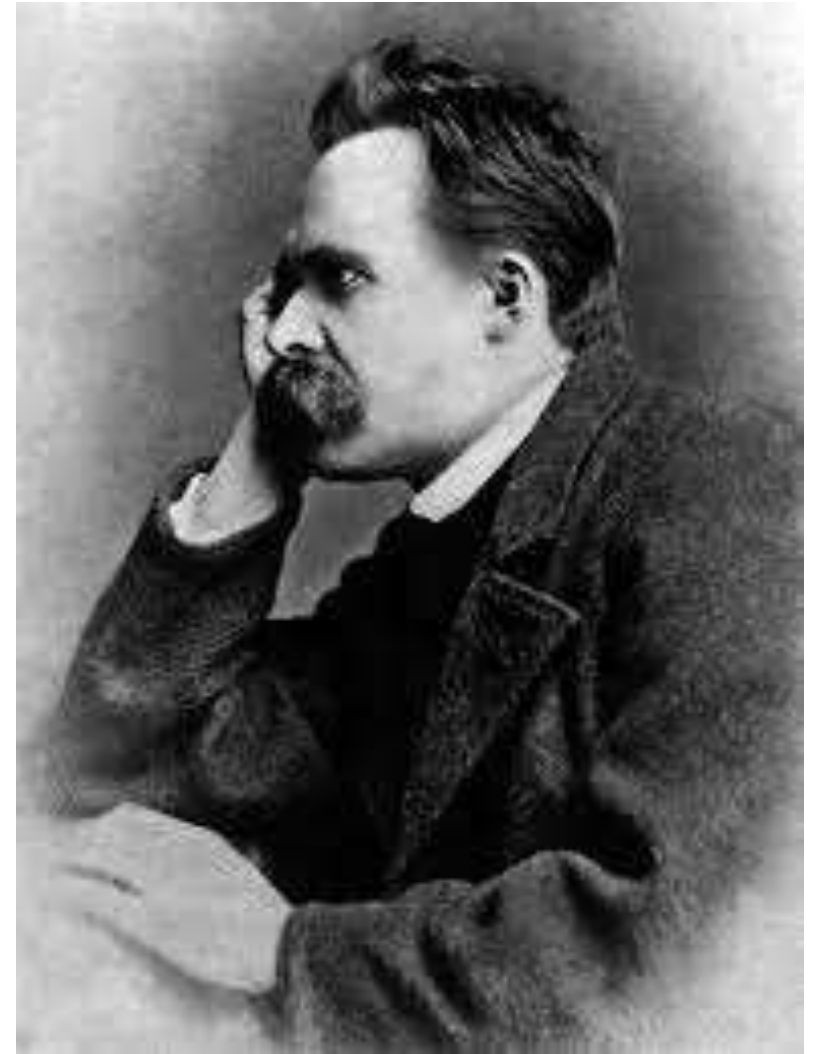
Rule 5: Aim for transparency; Show all the data;

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

Rule 7: Perform a proper global sensitivity analysis.

Quantitative story-telling

“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.”

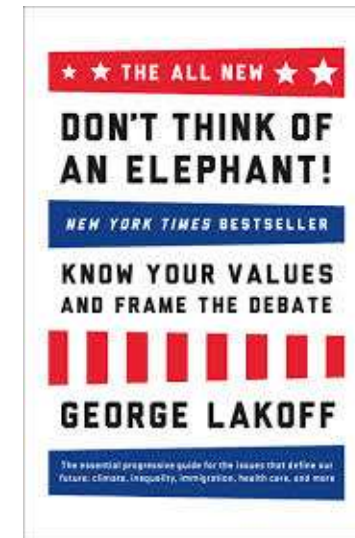


Frames

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)



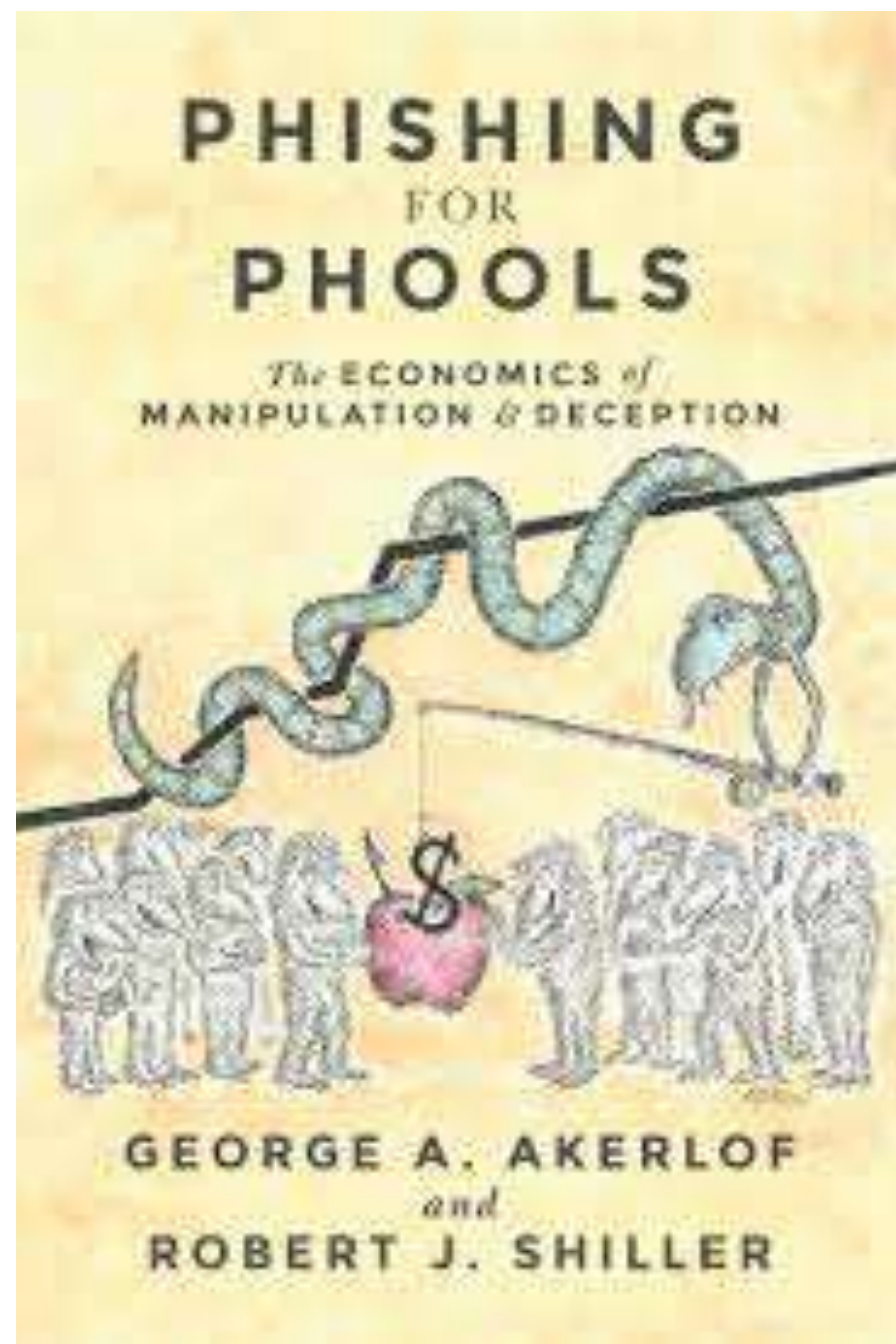
George Lakoff



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



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



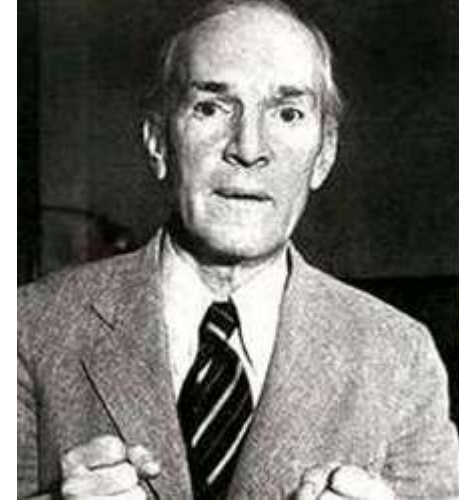
Robert R. Shiller

QST tests frames/narratives for:

- Misconstruction, internal contradictions, technical errors
- 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).

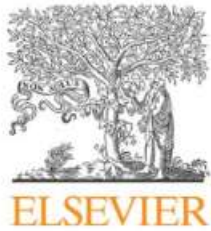
Why frames ‘stick’

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



Upton Sinclair

Some examples:
Sensitivity analysis: the
case of the Stern review



Contents lists available at ScienceDirect

Global Environmental Change

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



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

Andrea Saltelli*, Beatrice D'Hombres

Joint Research Centre, Institute for the Protection and Security of the Citizen, Ispra, Italy

Andrea
Saltelli

HOME ABOUT ME



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



William Nordhaus,
University of Yale



Nicholas Stern, London
School of Economics

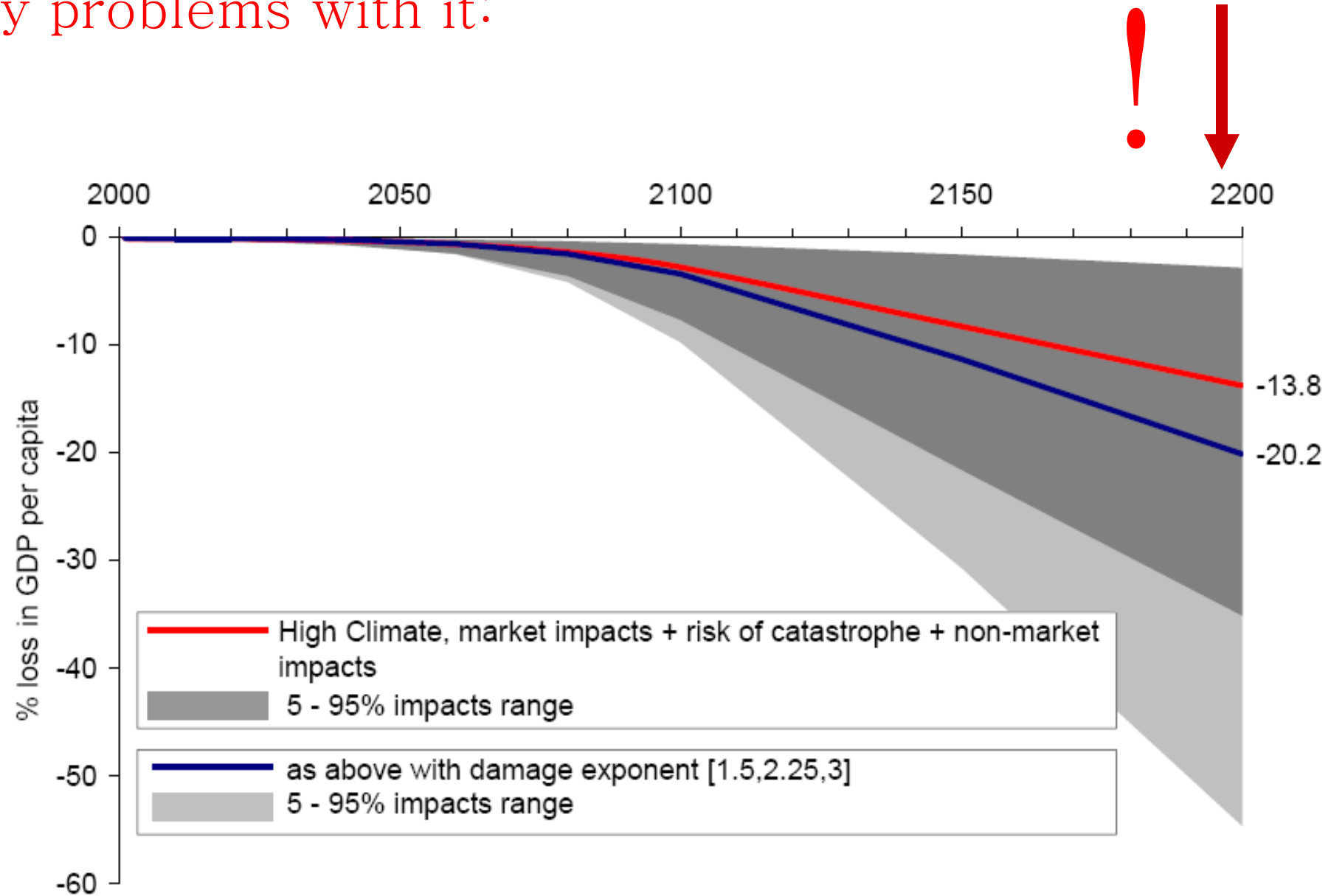
Stern, N., Stern Review on the Economics of Climate Change. UK Government Economic Service, London, www.sternreview.org.uk.

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

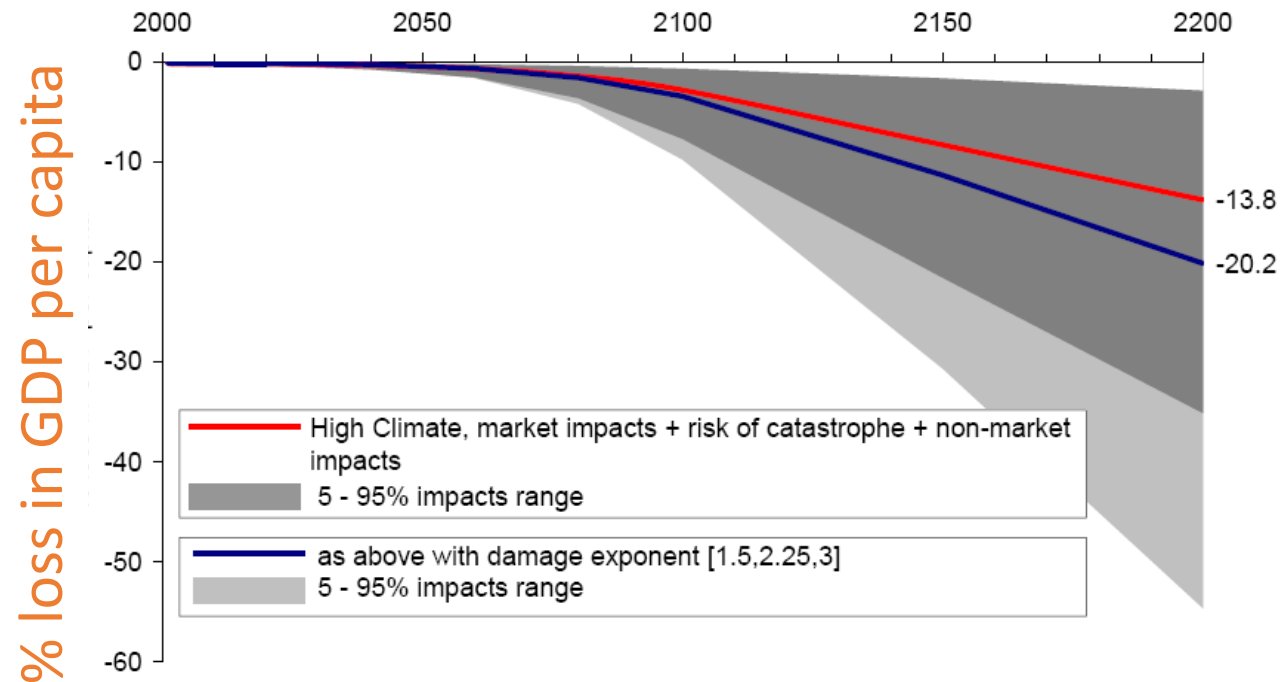
The Stern – Nordhaus exchange on *SCIENCE*

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

My problems with it:

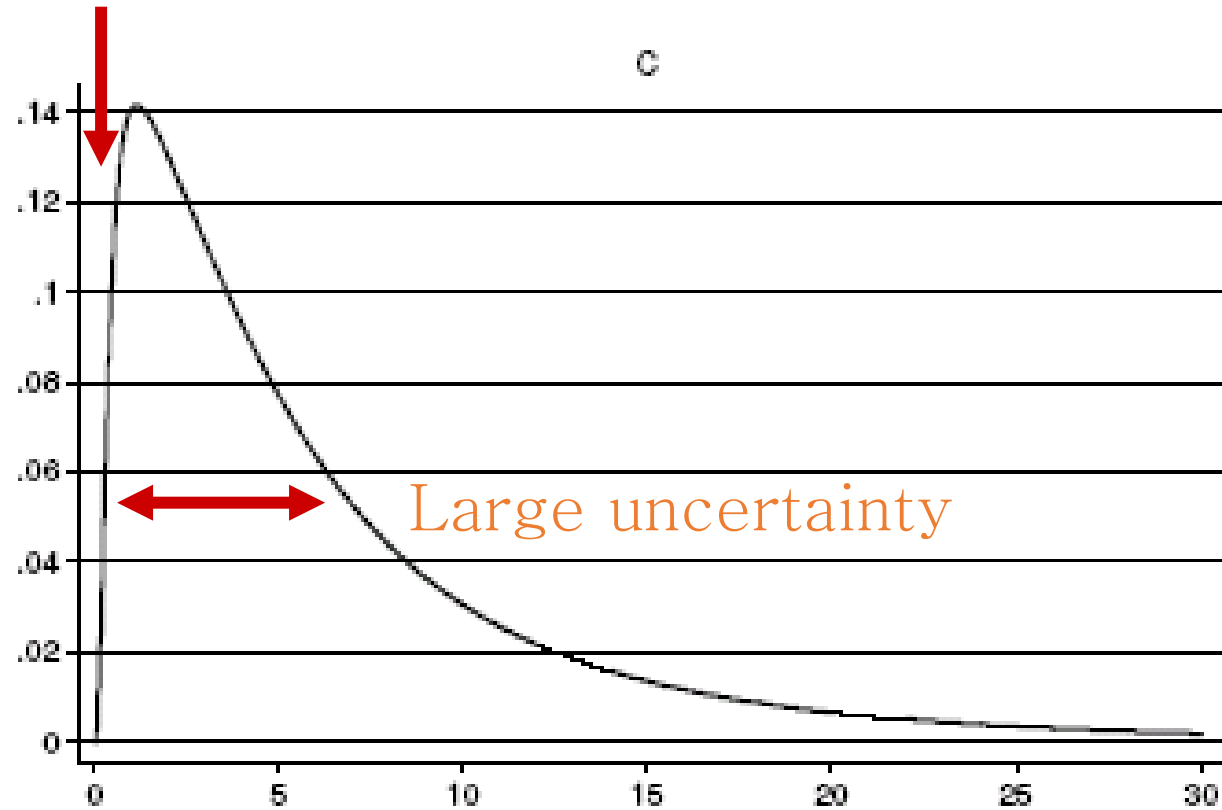


... but foremost Stern says:
changing assumptions → important effect
when instead he should admit that:
changing assumptions → all changes a lot



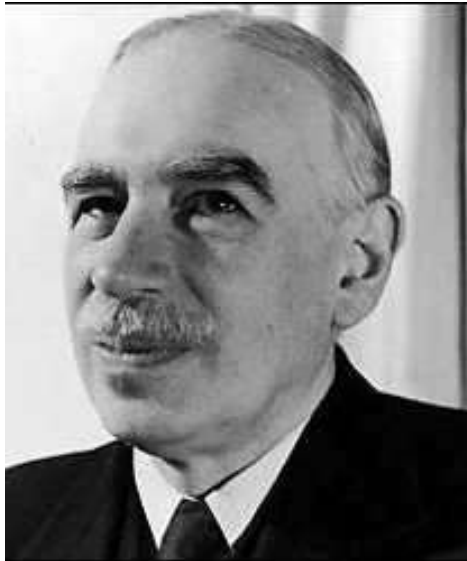
How was it done? A reverse engineering of the analysis

Missing points



% loss in GDP per capita

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



... precisely wrong

Some examples:

Sensitivity

auditing/Quantitative

storytelling: The

Ecological Footprint

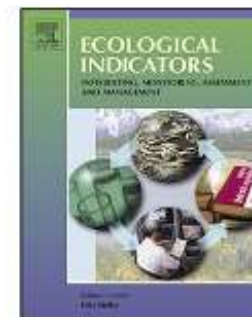


ELSEVIER

Contents lists available at [ScienceDirect](#)

Ecological Indicators

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



prints to nowhere

io Giampietro^{a,c}, Andrea Saltelli^{b,*}

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^c Institute for Research and Advanced Studies (ICREA), Passeig Lluís Companys, 23, 08010 Barcelona, Spain



CrossMark



[HOME](#) [ABOUT ME](#)



Giampietro, M., and Saltelli, A., 2014, Footprints to nowhere, Ecological Indicators, 46, 610–621.

Goldfinger, S., Wackernagel, M., Galli, A., Lazarus, E., Lin, D., 2014, Footprint facts and fallacies: A response to Giampietro and Saltelli (2014) “Footprints to Nowhere”, 46, 622–632.

Giampietro, M., and Saltelli, A., 2014, Footworking in Circles, Ecological Indicators, 46 (2014) 260–263.

Alessandro Galli , Mario Giampietro , Steve Goldfinger, Elias Lazarus, David Lin, Andrea Saltelli , Matthis Wackernagel , Felix Müller, 2016, Questioning the ecological footprint , Ecological Indicators, 69, 224–232.

All the story . . .



How many Chinas does it take to support China?

 CHINA 2.5   

What about some other countries?

 FRANCE 1.6  

 INDIA 1.8  

 U.S.A. 1.9  

 EGYPT 2.4   

 GREECE 3.1    

 U.K. 3.5    

 ITALY 4.0    

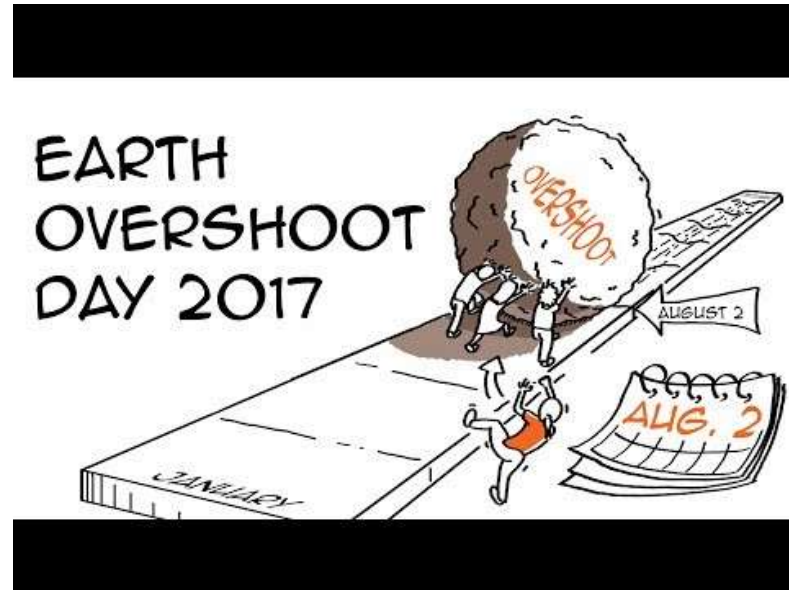
 SWITZER-
LAND 4.2     

 QATAR 5.7      

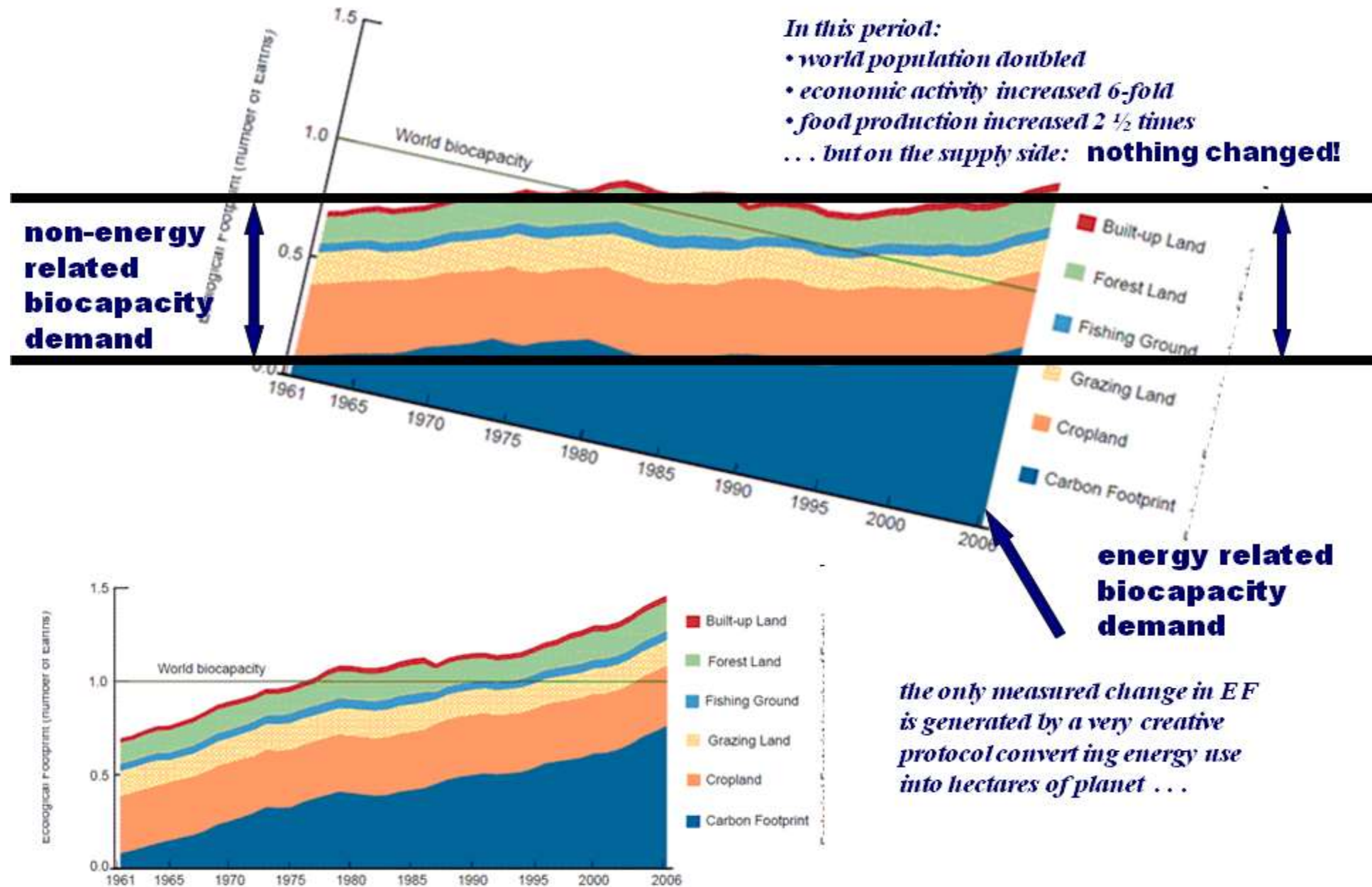
 JAPAN 7.1       

 WORLD 1.5  

Based on two “accounts (biocapacity and footprint) representing the supply and demand of renewable biological resources, and the area of forest required to offset human carbon emissions (the carbon footprint)” the EF tells mankind how many planets are being used



The change of world footprint in time (1961-2006)



The footprint is almost entirely driven by energy consumption, which corresponds to carbon emission which are in turn sequestered by forests; [...] Carbon sequestration rate is hence what drives the results

But this number could be made negative as well as infinity depending on what number one picks ... it is totally volatile

Is the EF a rhetorical device?

- The implausible accuracy (Earth overshoot day = August 2!)
- Offsetting a flow with a stock (Kg of CO₂ per year versus square meters of land)
- The anti-trade bias (CMEPSP, 2009, p. 71)
- The total dependence upon energy related pressures
- Paradoxical policy implications (e.g. in Agriculture)

Giampietro and Saltelli, Op. cit.

CMEPSP (2009). Commission on the Measurement of Economic Performance and Social Progress, URL: http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf last accessed June 2014.

Is the EF a rhetorical device?

- The EF is inconsistent with its stated purpose of measuring demand on ecosystems
- The EF depends mostly from a dimensionally flawed energy emissions assessment
- One cannot accept EF's flaws on the ground that the EF has normative virtues; EF's rhetoric muddles the sustainability debate

“EF measurements, as currently constructed and presented, are so misleading as to preclude their use in any serious science or policy context.[...] less than half the area of the United States planted with eucalypts could essentially give us an EF equal to one Earth—an approach that no ecologist would recommend.”

Blomqvist L, Brook BW, Ellis EC, Kareiva PM, Nordhaus T, et al. (2013a) Does the Shoe Fit? Real versus Imagined Ecological Footprints. PLoS Biol 11(11): e1001700.
doi:10.1371/journal.pbio.1001700.

See also follow up:

Rees WE, Wackernagel M (2013) The Shoe Fits, but the Footprint is Larger than Earth. PLoS Biol 11(11): e1001701. doi:10.1371/journal.pbio.1001701

Blomqvist L, Brook BW, Ellis EC, Kareiva PM, Nordhaus T, et al. (2013b) The Ecological Footprint Remains a Misleading Metric of Global Sustainability. PLoS Biol 11(11): e1001702.
doi:10.1371/journal.pbio.1001702.

Some examples:
Sensitivity
auditing/Quantitative
storytelling: scenarios
for food security



DISCUSSION PAPER

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

Andrea Saltelli^{1,2,3}  • Samuele Lo Piano¹

Accepted: 4 August 2017 / Published online: 15 August 2017
© Springer International Publishing AG 2017

Andrea
Saltelli

HOME ABOUT ME

CAETERIS ARE
NEVER PARIBUS



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

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

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

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



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

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

Three digits



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

*Authors' estimate

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

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

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



Our study:

- Balancing hectares growth and population growth (our computation) results in no change in food per capita at planetary scale
- Neglect of diminishing returns and ecosystem stress (fertilizers, pesticides)

Our study:

- More adults (higher caloric intake) in 2050 population
- Can one educate citizens globally? The case of tobacco

In conclusion the

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

is the substitution of a political problem with a technical one

Some examples:

Sensitivity

auditing/Quantitative

storytelling: Golden

Rice's story

Speaking of Science

107 Nobel laureates sign letter blasting Greenpeace over GMOs

By Joel Achenbach June 29

<https://www.washingtonpost.com/news/speaking-of-science/wp/2016/06/29/more-than-100-nobel-laureates-take-on-greenpeace-over-gmo-stance/>



While Greenpeace and other organizations oppose genetically engineered food, more than 100 Nobel laureates are taking a stand on the side of GMOs. Here's a look at each side's arguments. (Jenny Starrs/The Washington Post)

“While Greenpeace and other organizations oppose genetically engineered food, more than 100 Nobel laureates are taking a stand on the side of GMOs. Here's a look at each side's arguments. (Jenny Starrs/The Washington Post)”

From the Nobel laureates' letter:

“Greenpeace has spearheaded opposition to Golden Rice, which has the potential to reduce or eliminate much of the death and disease caused by a vitamin A deficiency (VAD), which has the greatest impact on the poorest people in Africa and Southeast Asia.

[...] a total of one to two million preventable deaths occur annually as a result of VAD, [...] VAD itself is the leading cause of **childhood blindness globally affecting 250,000 – 500,000 children each year. Half die within 12 months of losing their eyesight**”

From the Nobel laureates' letter:

“[...] Opposition based on emotion and dogma contradicted by data must be stopped.

How many poor people in the world must die before we consider this a "**crime against humanity**"?"

Opposing evidence on Golden Rice

Nutritionally: not enough beta carotene

Golden rice not authorized yet

More politically viable alternative successful

Dangerous colour

Low yield of the modified variety ...

<http://www.ecowatch.com/greenpeace-to-nobel-laureates-its-not-our-fault-golden-rice-has-failed-1896697050.html>

With Mario Giampietro and Tiziano Gomiero



**Forcing consensus is bad for science
and society**

May 12, 2017 4:38pm AEST

<https://theconversation.com/forcing-consensus-is-bad-for-science-and-society-77079>

.



Consume GMO because they are safe!



GMO as a food scare

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



Citizens' worries (Marris, 2001, excerpts)

- Who decided that they should be developed and how?
- 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?

Marris, C., Wynne, B., Simmons P., and Weldon, S. 2001. Final Report of the PABE research project funded by the Commission of European Communities, Contract number: FAIR CT98-3844 (DG12 - SSMI), December 2001.

US National Academy of Sciences report on genetically engineered crops:

“Products of new technologies should be regulated not only on the basis of their benefit–risk profiles, but also on their societal context and need”

Hunter, J., Duff, G., GM crops—lessons from medicine, *Science*, 353, 1187 (2016)

Some examples:
Quantitative storytelling:
Cost Benefit Analyses

The myth of scientific quantification via risk or cost benefit analyses, including of the impact of new technologies, has been at the hearth of the critique of the ecological moment (e.g. Schumacher, 1973; Winner, 1986; Funtowicz and Ravetz, 1994)

E. F. Schumacher, 1973, *Small Is Beautiful. Economics as if People Mattered*, Penguin Perennial,

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.

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

[...] quality is much more difficult to 'handle' than quantity, just as the exercise of judgment is a higher function than the ability to count and calculate.

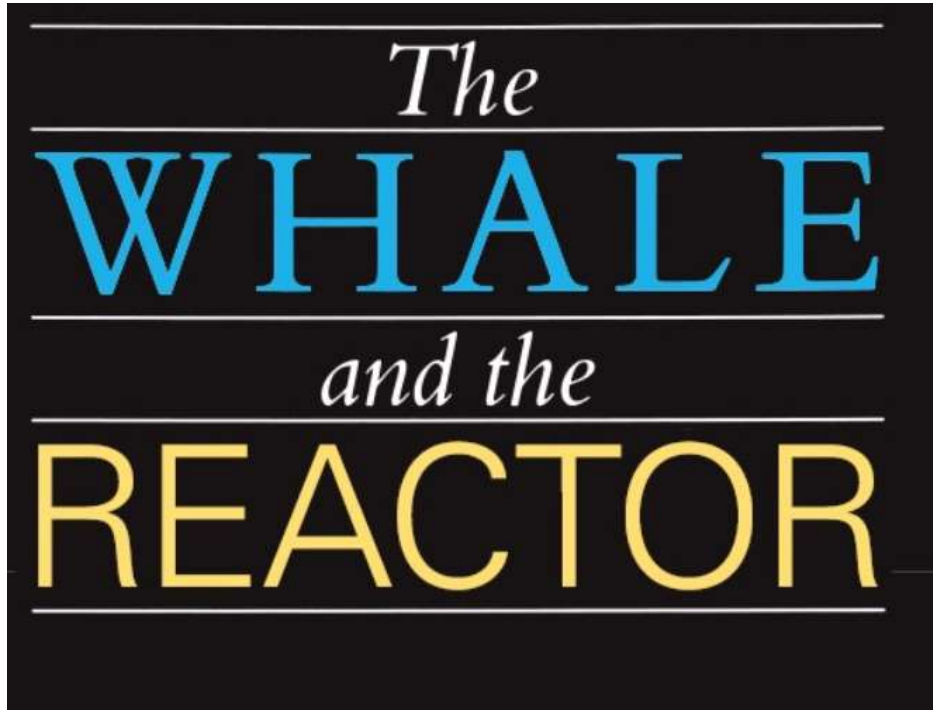


Ernst Friedrich
"Fritz"
Schumacher

Quantitative [values give] the appearance of scientific precision, even when this precision has been purchased by the suppression of vital differences of quality.

E. F. Schumacher, 1973, *Small Is Beautiful. Economics as if People Mattered*, Penguin Perennial,

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

Read chapter 8

8

ON NOT HITTING
THE TAR-BABY



Langdon Winner

On not falling into the trap of CBA
and risk analyses

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.

END

Twitter:
@andreasaltelli

Some examples:
Sensitivity auditing: the
OECD PISA study

Do PISA data justify PISA-based education policy?

PISA-based
education
policy

With Luisa Araújo and
Sylke V. Schnepf



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

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2396-7404

DOI 10.1108/IJCED-12-2016-0023





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

June 12, 2017 3:55pm AEST

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



A condensed version of the article

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

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

the **guardian**

OECD and Pisa tests are damaging education worldwide - academics

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



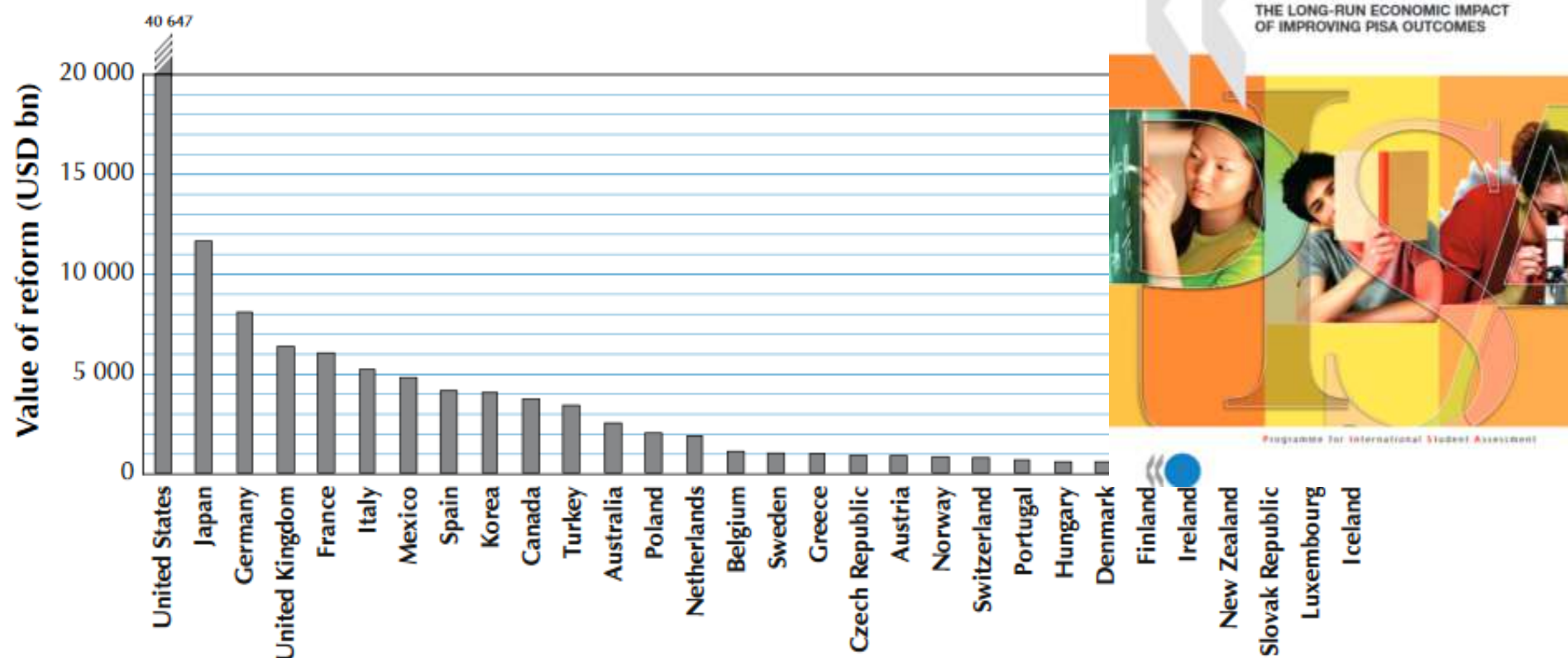
① School children in Sichuan province in China. Academics say the OECD should develop alternatives to league tables and find more meaningful ways of reporting assessment, taking account of different cultures. Photograph: James Zeng Huang/Corbis Sygma

Critical remarks by the 80 signatories of the letter:

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

Figure 1

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



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

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

PISA's daring quantifications:

“If every EU Member State achieved an improvement of 25 points in its PISA score as Germany and Poland did over the last decade, the GDP of the whole EU would increase by between 4% and 6% by 2090;

such an 6% increase would correspond to 35 trillion Euro”

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

We find both technical and normative issues:

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

2) Non open data, which makes SA impossible

3) Flattening curricula (do all countries wish to prosper by becoming knowledge societies?)

4) Power implications: power in the use of evidence. OECD (unelected officers and scholars) becoming a global super-ministry of education