



How not to do a sensitivity analysis

Andrea Saltelli, virtual
November 8 2022

- LUT University, Lappeenranta, Finland,
- Schulich School of Business, York University, Toronto, Canada, and
- Stanford University, CA, USA



Where to find this talk: www.andreasaltelli.eu

Andrea Saltelli[HOME](#)[ABOUT ME](#)[PUBLICATIONS](#)[NEWS & VIDEOS](#)[RESOURCES](#)

CAETERIS ARE
NEVER PARIBUS

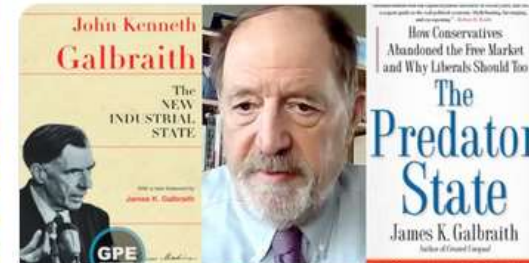
Tweets by @AndreaSaltelli



andrea saltelli
@AndreaSaltelli

Worth listening all; pay heed to the bit at 31'.50".
Why economics needs to pay heed to its
biophysical bases [@ICTA_UAB](#) [@g_kallis](#)

Resource Limits to American Capitalism & the
Predator State Today - % [GPEnewsdocs.com](#)
% [gpenewsdocs.com/resource-limit...](#)



Resource Limits to American Capitalis...

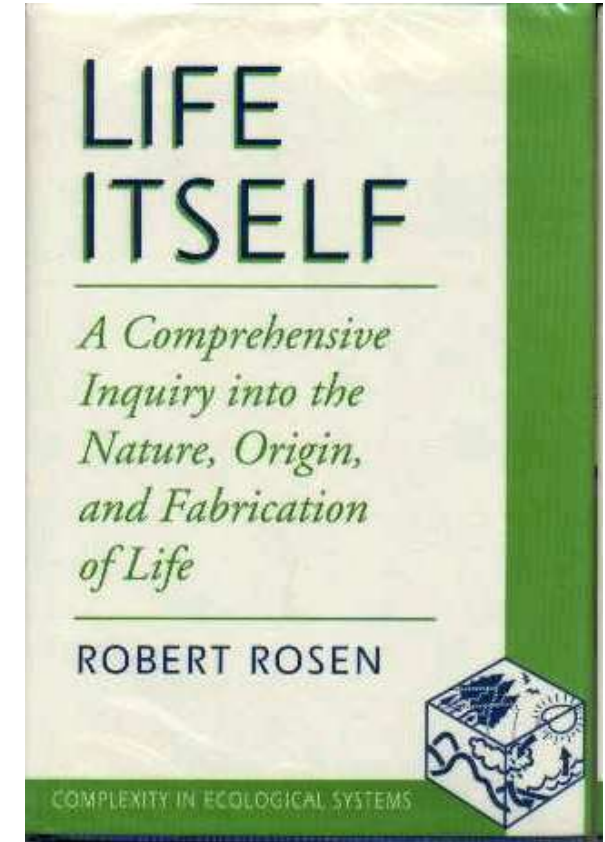
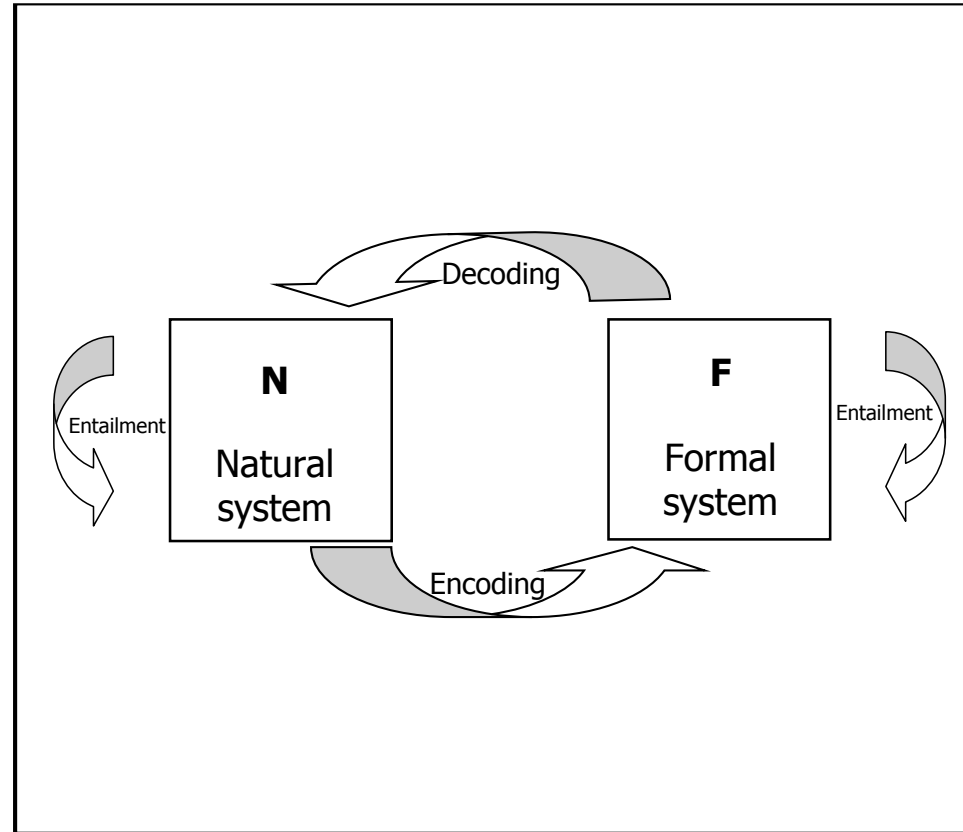
James K. Galbraith discusses the shift of ...
[gpenewsdocs.com](#)

[Embed](#)[View on Twitter](#)

Something general about
mathematical modelling

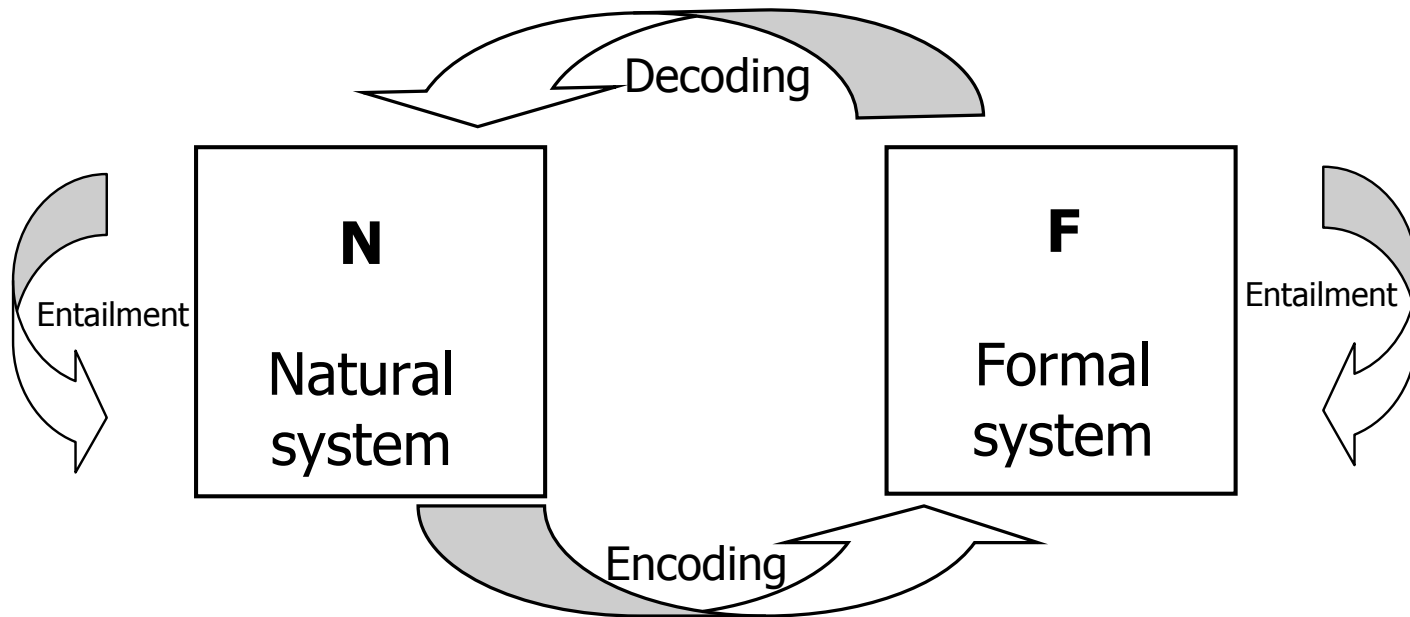
Modelling is a
craft more than
a science

Modelling as a craft rather than as a science for Robert Rosen



R. Rosen, *Life Itself: A Comprehensive Inquiry Into the Nature, Origin, and Fabrication of Life*. Columbia University Press, 1991.

Louie, A.H. 2010. "Robert Rosen's Anticipatory Systems." Edited by Riel Miller. *Foresight* 12 (3): 18–29. <https://doi.org/10.1108/14636681011049848>.



What is a model ?



Robert Rosen

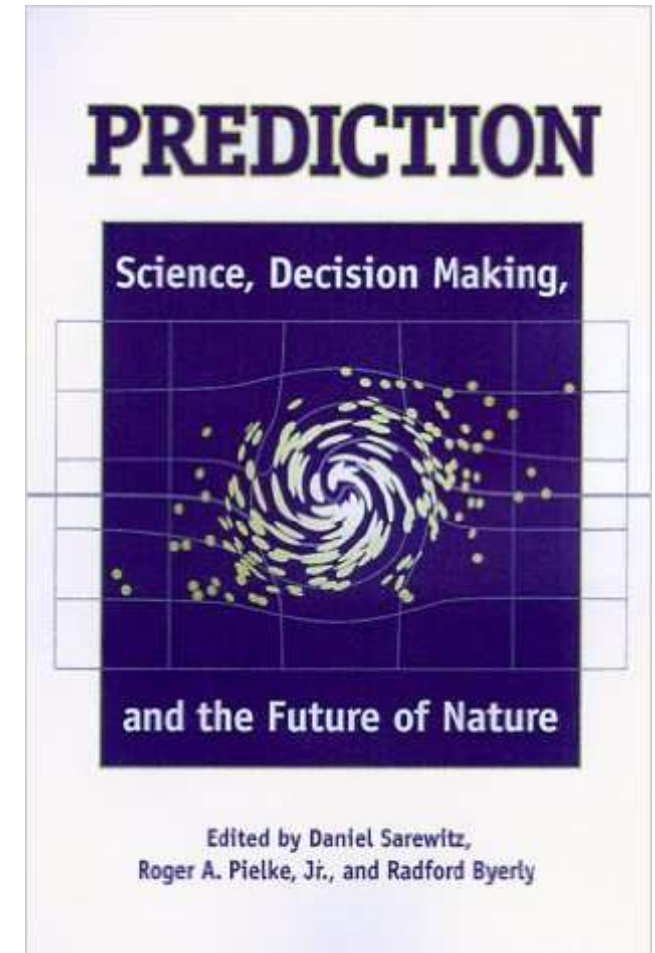
“models are most useful when they are used to challenge existing formulations, rather than to validate or verify them”



Naomi
Oreskes

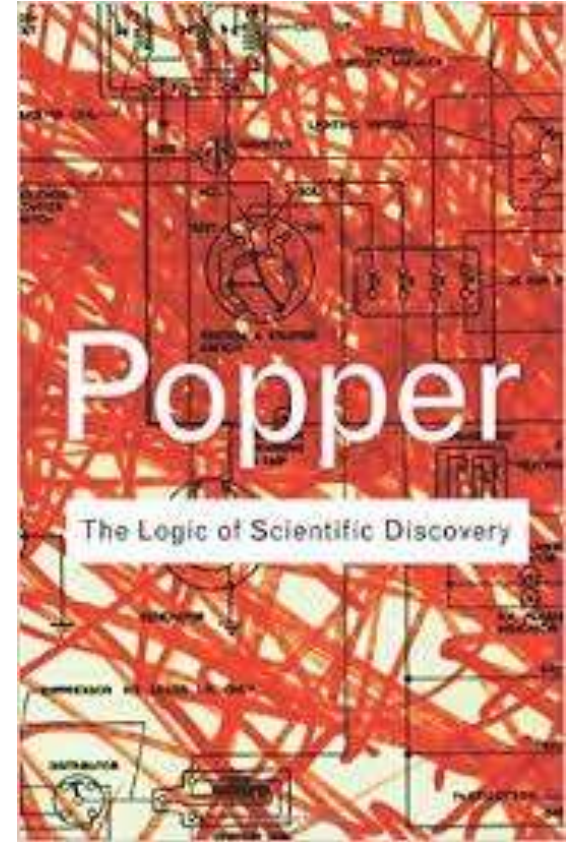
N. Oreskes, K. Shrader-Frechette, and K. Belitz, “Verification, Validation, and Confirmation of Numerical Models in the Earth Sciences,” *Science*, 263, no. 5147, 1994.

Models are not physical laws



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

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



“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”

Models have
little memory

“[...] The process of constructing and validating [value-at risk] models is time consuming and detail oriented; normally even the people who produced the model will not remember many of the assumptions incorporated into it, short of redoing their work, which means that the client cannot simply ask then what went into it.”

E. Millgram The Great Endarkenment, p. 29

Caeteris are never paribus

Ceteris paribus or caeteris paribus is a Latin phrase meaning "all other things being equal" or "other things held constant" or "all else unchanged" (Wikipedia)

The case of DSGE, dynamic stochastic general equilibrium models

Rational expectations of agents
Efficient market hypothesis

Philip Mirowski

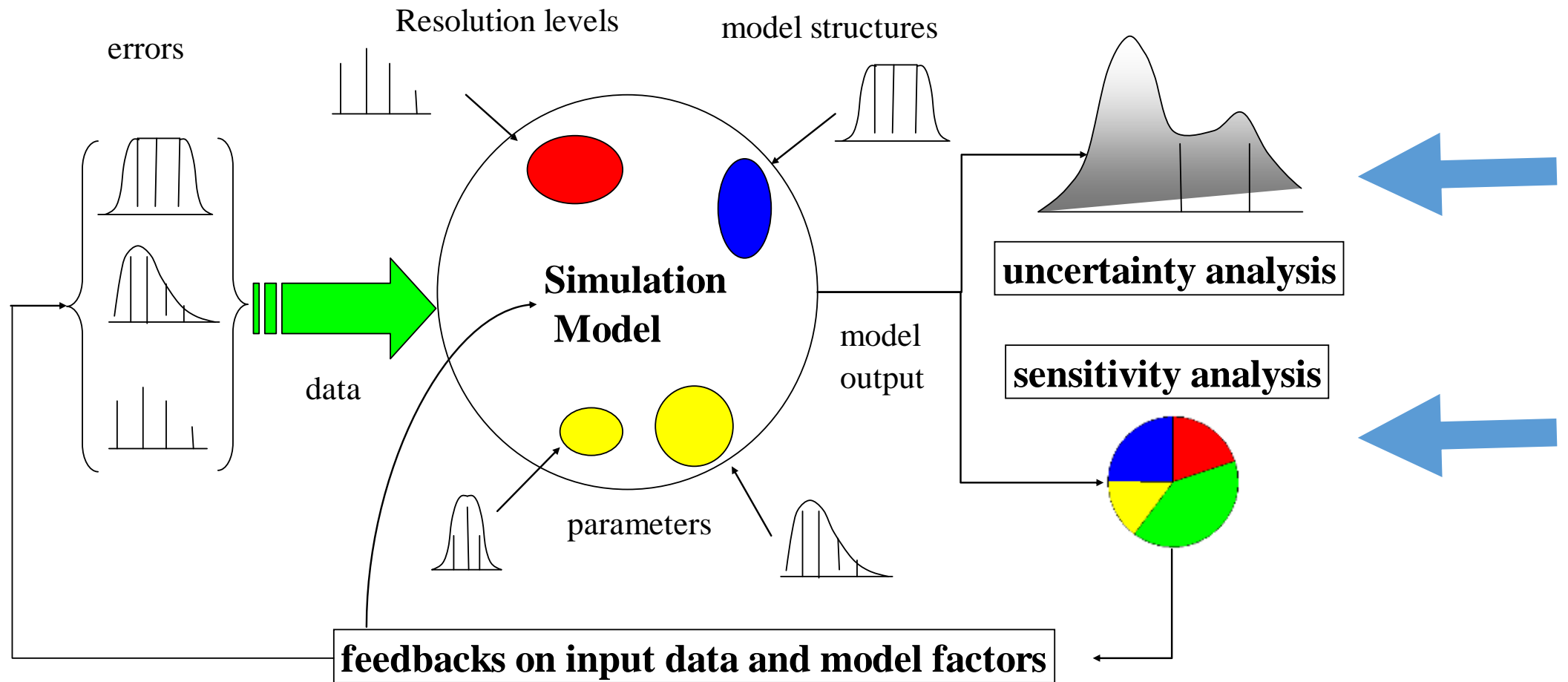


Philip Mirowski, 2013, Never let a serious crisis go wasted, Verso Books.

The US senate and Queen Elisabeth perplexed...

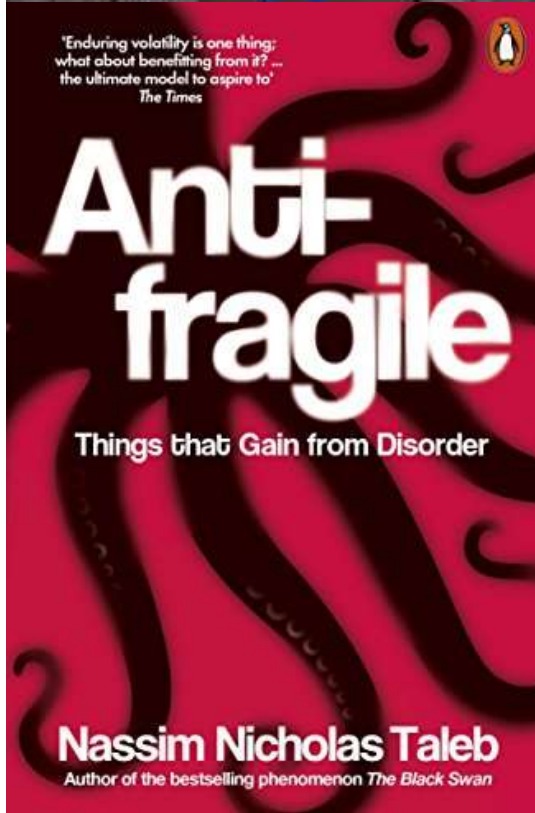


Philip Mirowski, 2013, Never let a serious crisis go wasted, Verso Books.





A short trip through sensitivity analysis borrowing N. N. Taleb's *via negativa*



Environmental Modelling & Software

Volume 114, April 2019, Pages 29-39



Why so many published sensitivity analyses are false: A systematic review of sensitivity analysis practices

Andrea Saltelli ^{a, b}  , Ksenia Aleksankina ^c, William Becker ^d, Pamela Fennell ^e, Federico Ferretti ^d,
Niels Holst ^f, Sushan Li ^g, Qiongli Wu ^h

Don't use just any method

Use the method appropriate to context and purpose

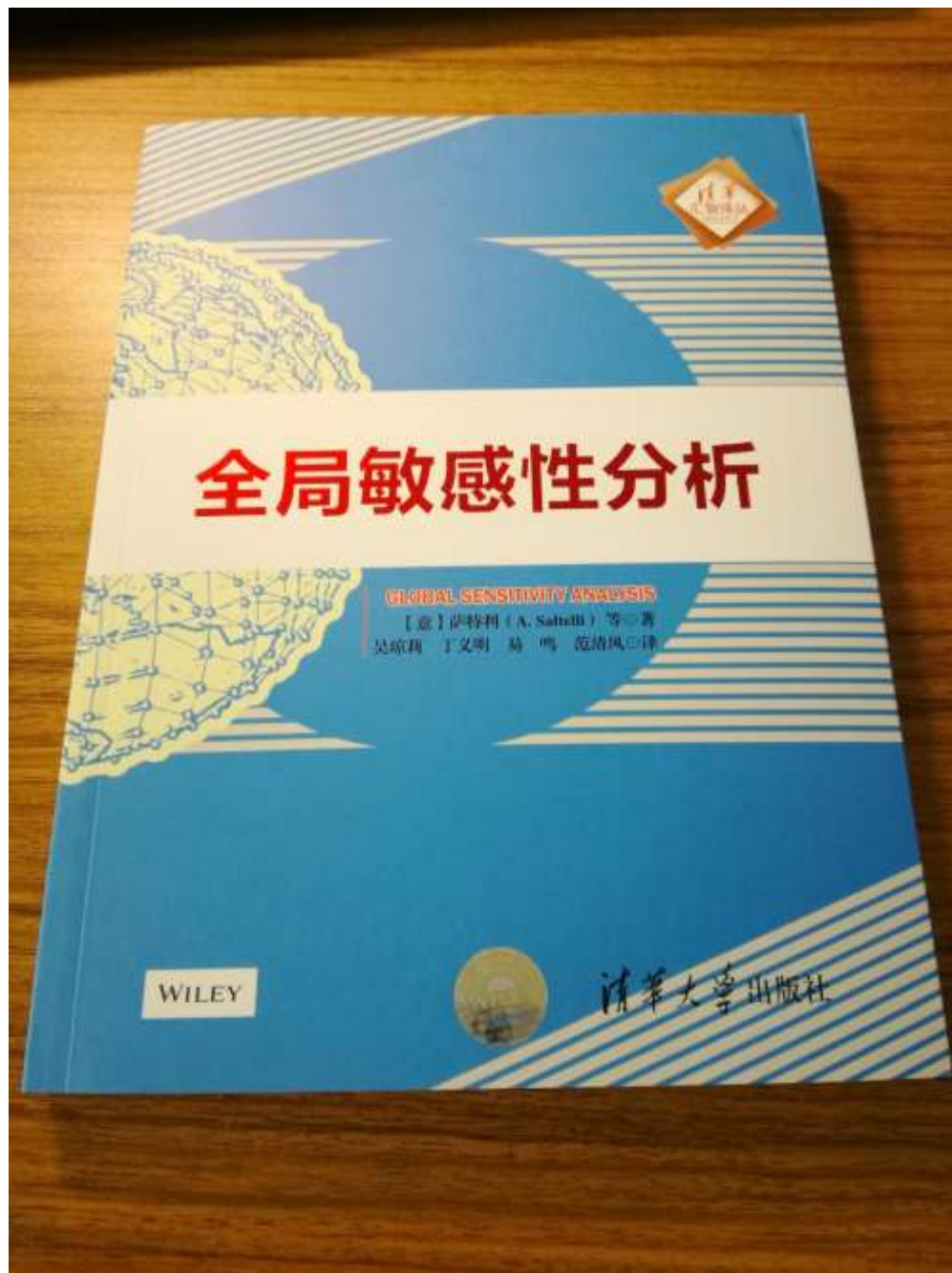
An introduction to variance based methods

A. Saltelli, M. Ratto,
T. Andres, F. Campolongo,
J. Cariboni, D. Gatelli,
M. Saisana, S. Tarantola

GLOBAL SENSITIVITY ANALYSIS

The Primer

 WILEY





A. Saltelli, M. Ratto,
T. Andres, F. Campolongo,
J. Cariboni, D. Gatelli,
M. Saisana, S. Tarantola

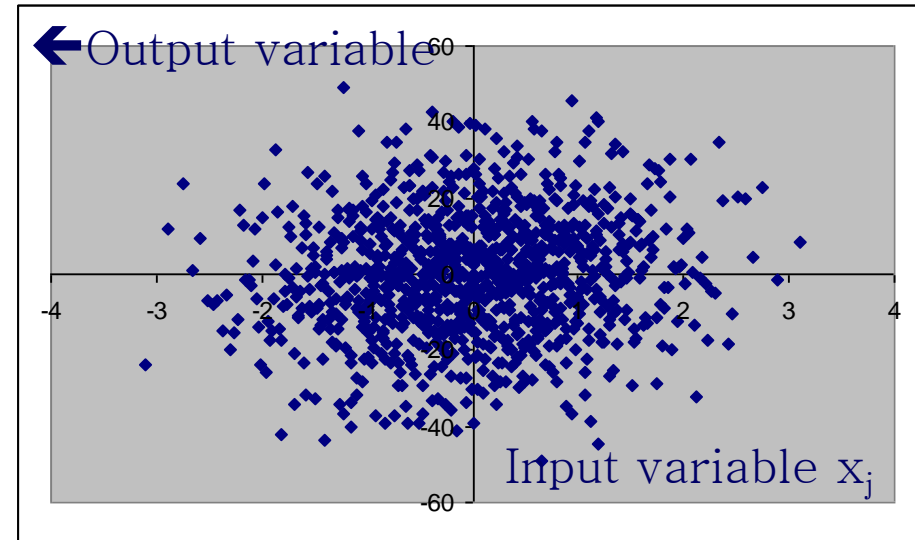
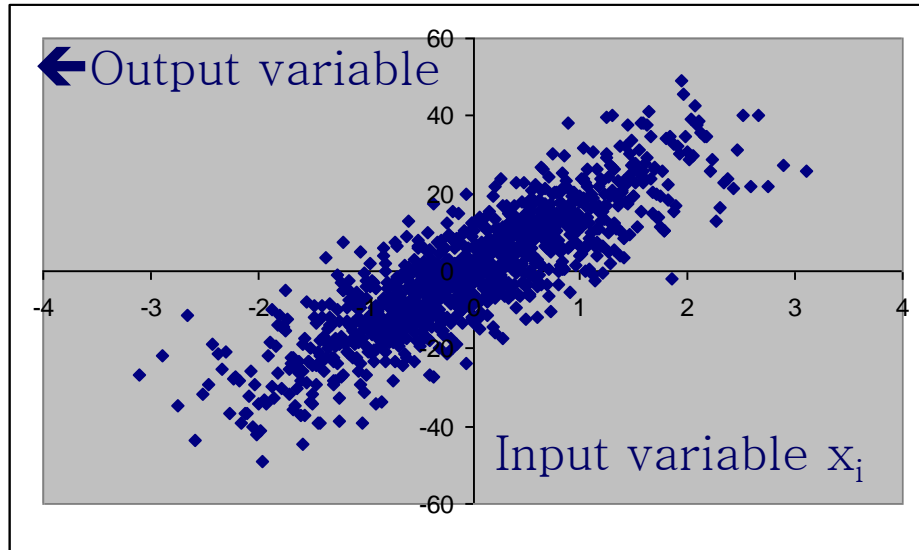
GLOBAL SENSITIVITY ANALYSIS

The Primer

 WILEY

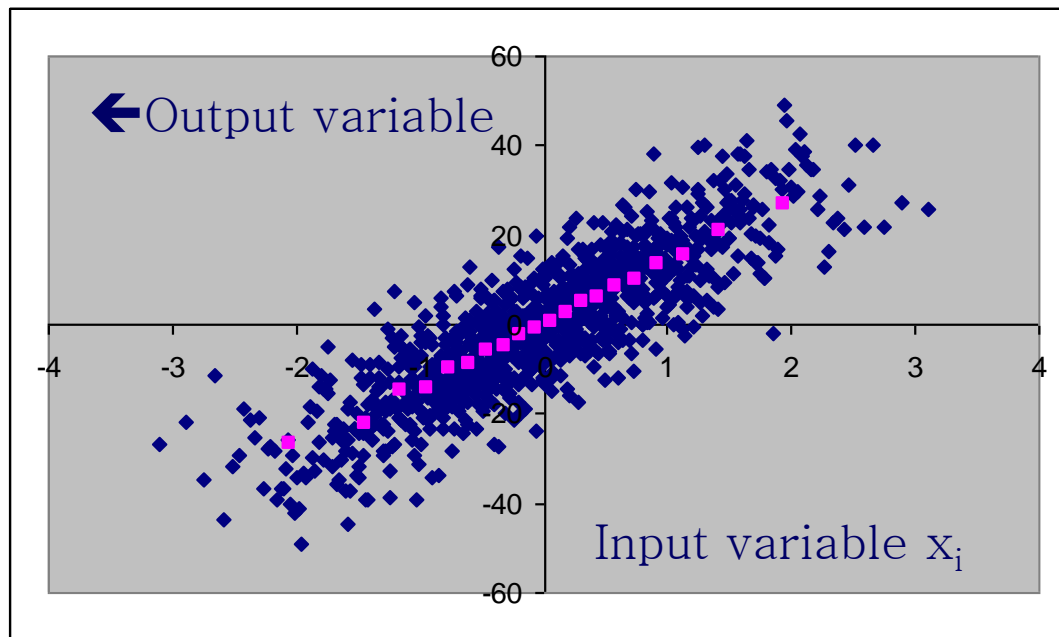
Available for free at

<http://www.andreasaltelli.eu>



Plotting the output as a function of two different input factors

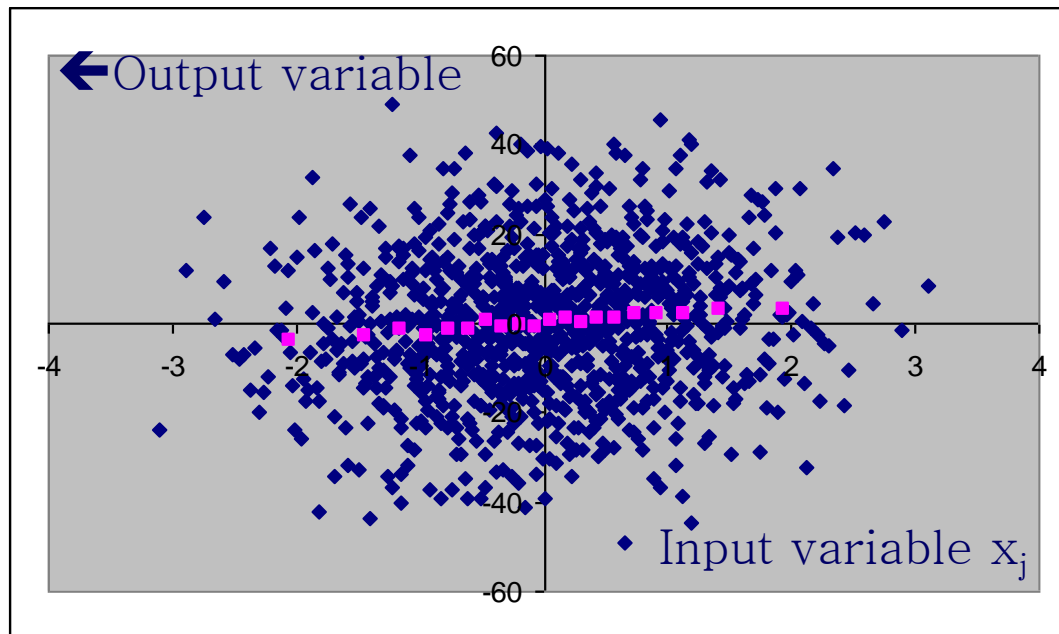
Which factor is more important?

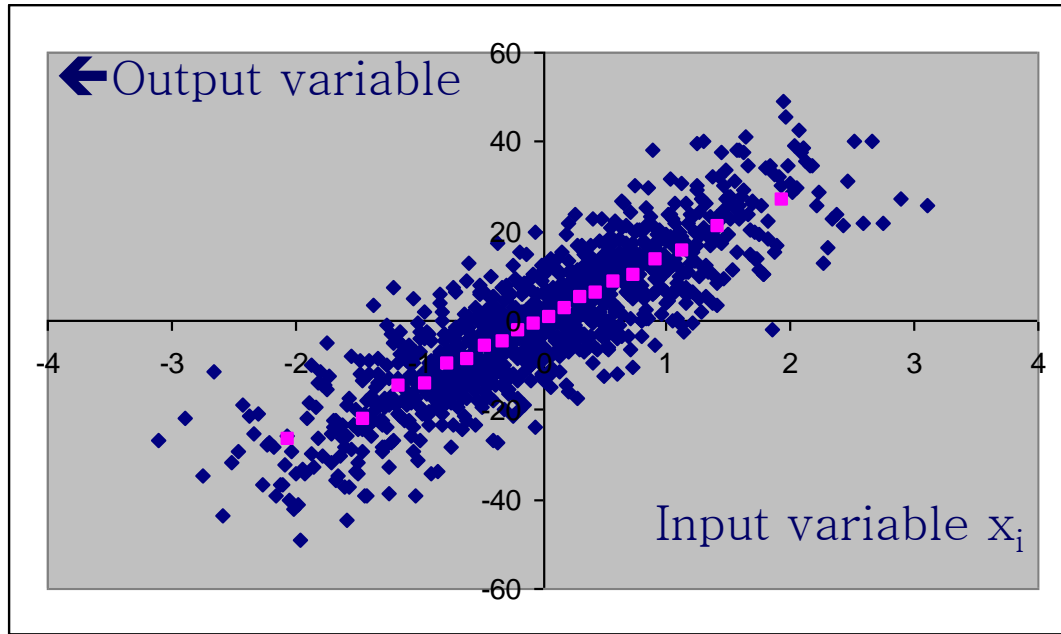


~1,000 blue points

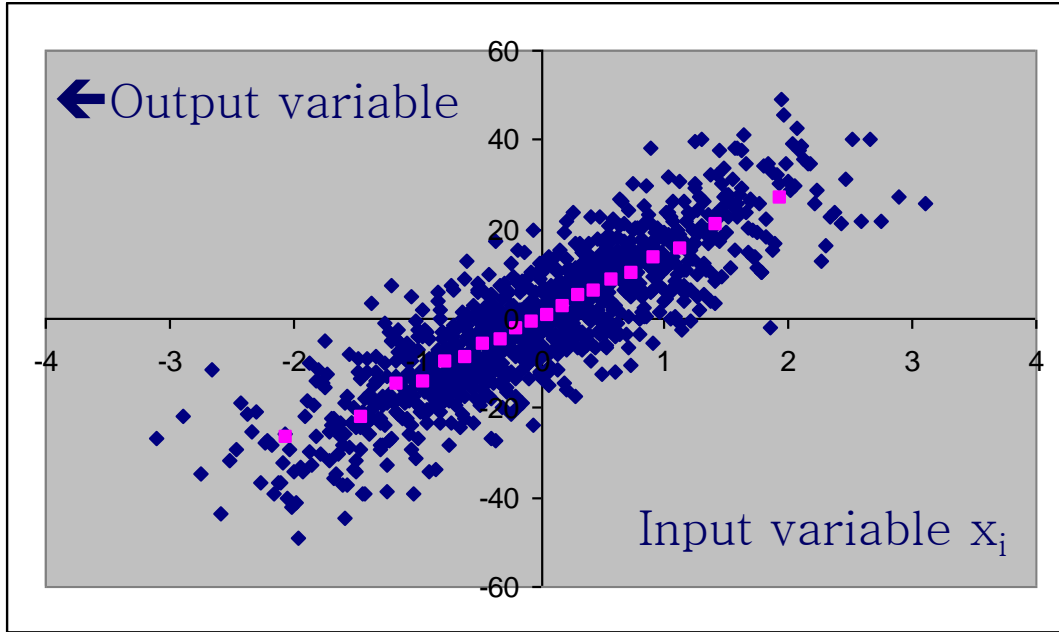
Divide them
in 20 bins of
~ 50 points

Compute the
bin's average
(pink dots)



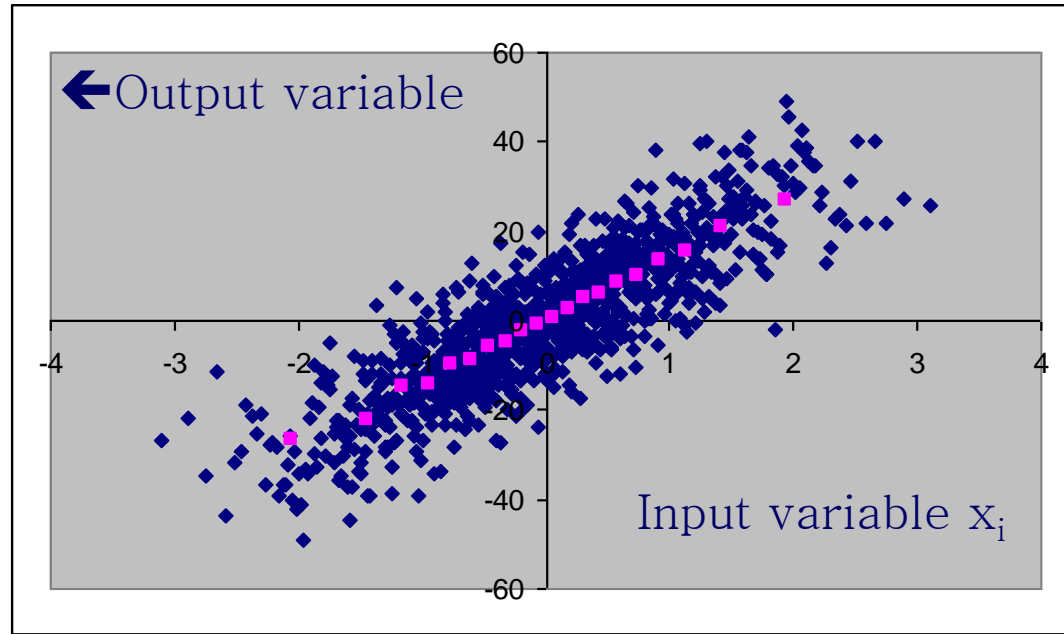


Each pink point is $\sim E_{\mathbf{x}_{\sim i}}(Y|X_i)$

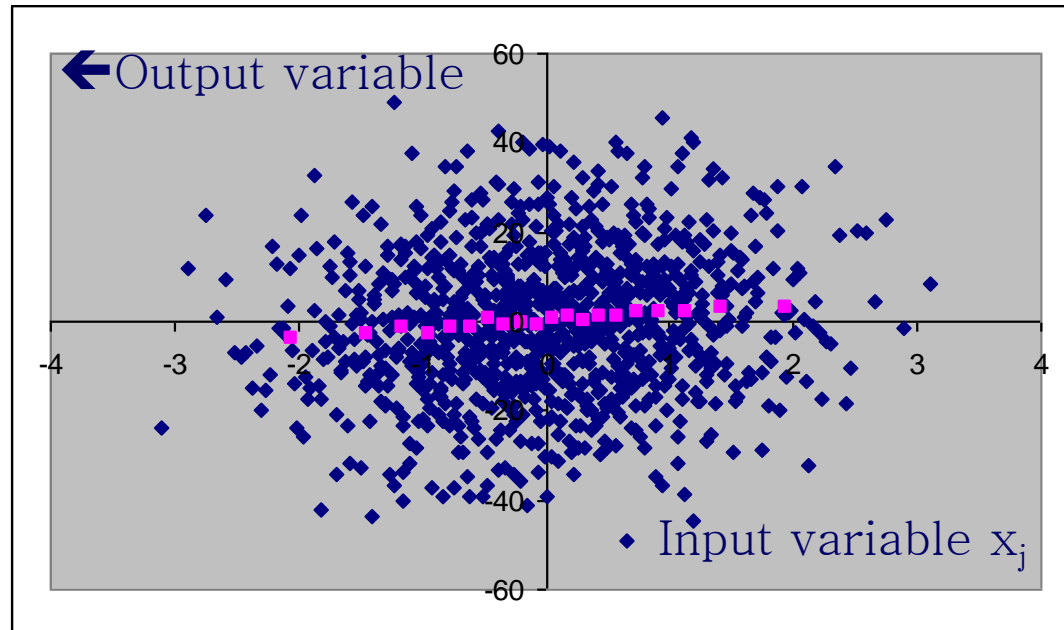


Take the variance of
the pink points one
obtains a sensitivity
measure

$$V_{X_i} \left(E_{\mathbf{X}_{\sim i}} (Y | X_i) \right)$$



Which factor
has the highest
 $V_{X_i} \left(E_{\mathbf{x}_{\sim i}} (Y | X_i) \right)$?



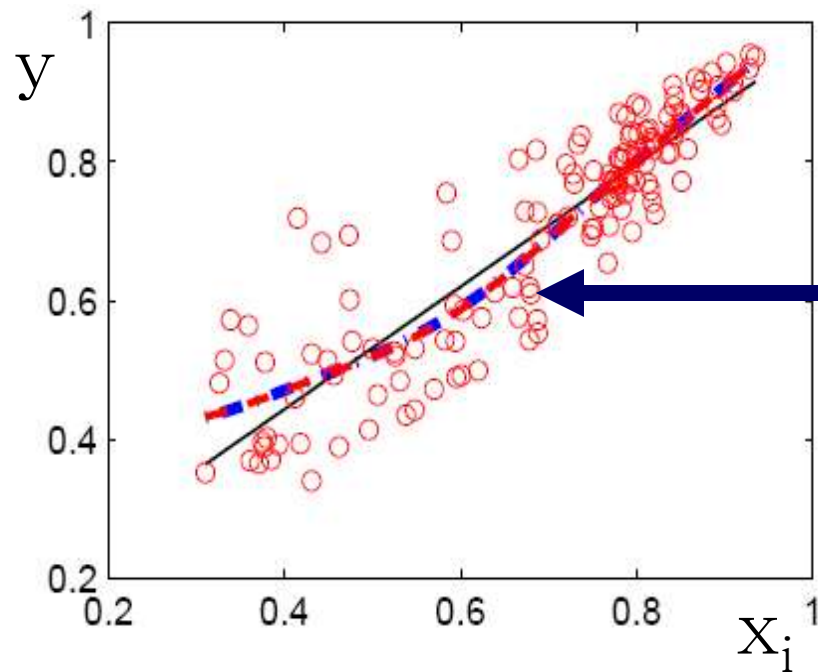
For additive models one can decompose the total variance as a sum of those partial variances

$$\sum_i V_{X_i} \left(E_{\mathbf{X}_{\sim i}} (Y | X_i) \right) \approx V(Y)$$

... which is also how additive models are defined

$$S_i = \frac{V_{X_i} \left(E_{\mathbf{x}_{\sim i}} (Y | X_i) \right)}{V(Y)}$$

The partial variance divided by the total variance is the so-called sensitivity index of the first order, identical in formulation to Pearson's correlation ratio



Smoothed curve:

$$\mathbf{E}_{\mathbf{x}_{\sim i}} (y \mid x_i)$$

First order
sensitivity index:

$$\frac{V_{x_i} (\mathbf{E}_{\mathbf{x}_{\sim i}} (y \mid x_i))}{V(y)}$$

Pearson's correlation
ratio

Smoothed curve

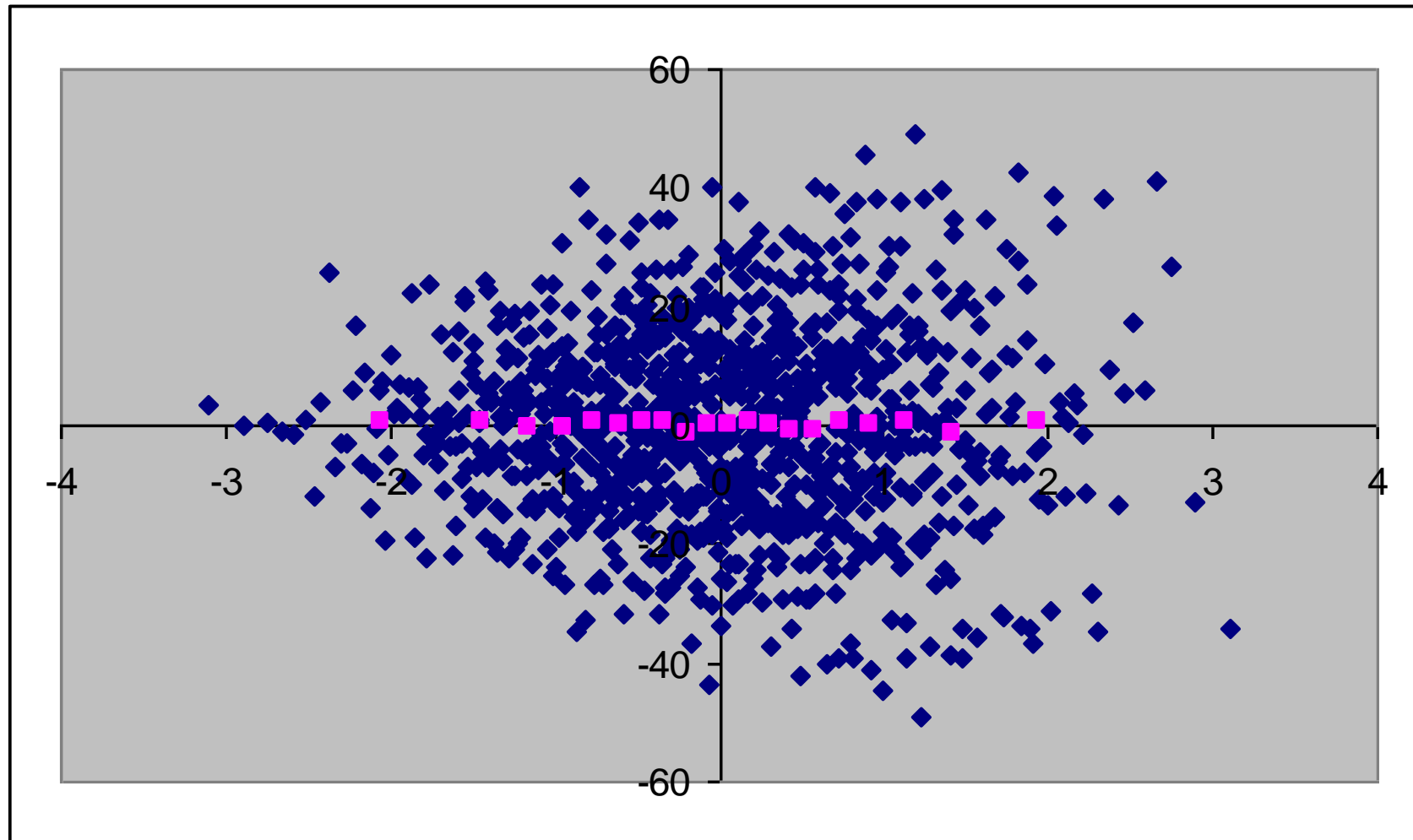
$$S_i \equiv \eta_i^2 := \frac{V_{x_i} (\mathbf{E}_{\mathbf{x}_{\sim i}} (y \mid x_i))}{V(y)}$$

First order sensitivity index

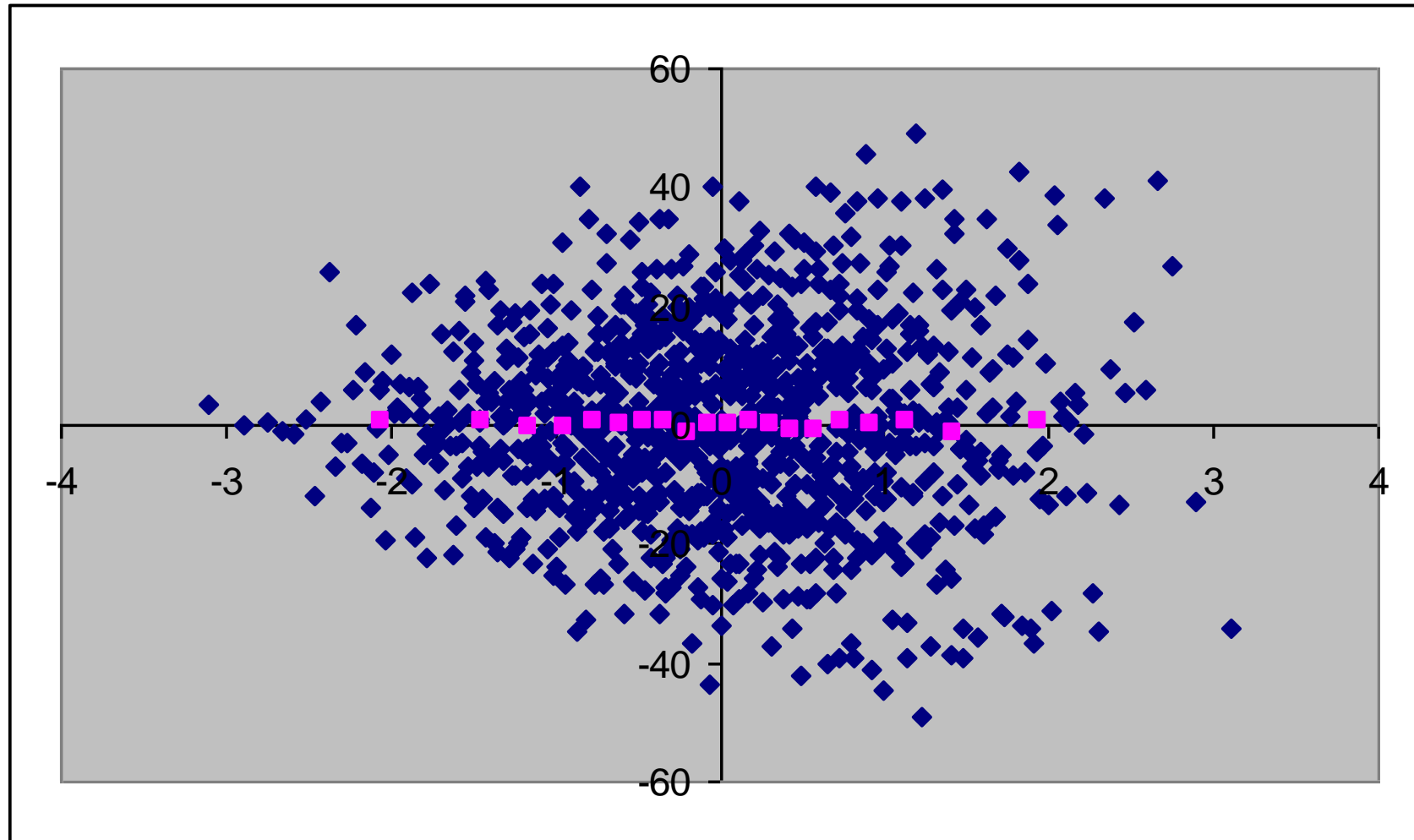
Unconditional
variance

Non additive models

Is $S_i = 0$?



Is this factor non-important?



There are terms which capture
two-way, three way, \cdots interactions
among variables

All these terms are linked by a
formula

Variance decomposition (ANOVA)

$$V(Y) =$$

$$\sum_i V_i + \sum_{i,j>i} V_{ij} + \dots + V_{123\dots k}$$

Variance decomposition (ANOVA)

The total variance can be decomposed into main effects and interaction effects up to the order k , the dimensionality of the problem (only for independent factors)

If fact interactions terms are awkward to handle: **just the second order terms** for a model with k factors are as many as $k(k-1)/2 \dots$

(10 factors=45 second order terms)

How about a single ‘importance’ terms for all effects?

In fact such terms exist and can be computed easily, without knowledge of the individual interaction terms

Thus given a model $f(X_1, X_2, \dots, X_3)$

Where the variance decomposition would

read $1 = S_1 + S_2 + S_3 + S_{12} + S_{13} + S_{23} + S_{123}$

We compute

$$T_1 = S_1 + S_{12} + S_{13} + S_{123}$$

$$T_2 = S_2 + S_{12} + S_{23} + S_{123}$$

$$T_3 = S_3 + S_{13} + S_{23} + S_{123}$$

The measures and their ‘settings’ = when to use them



Journal of the American Statistical Association >

Volume 97, 2002 - Issue 459

Enter keywords, authors, DOI, C

[Submit an article](#)

[Journal homepage](#)

979

Views

286

CrossRef citations
to date

6

Altmetric

Primary Article

On the Relative Importance of Input Factors in Mathematical Models

Safety Assessment for Nuclear Waste Disposal

Andrea Saltelli & Stefano Tarantola

Pages 702-709 | Published online: 31 Dec 2011

Download citation <https://doi.org/10.1198/016214502388618447>

The measures and their ‘settings’
= when to use them

First order effect	Factor prioritization (orienting research)
Total effect	Factor fixing (model simplification)



Making best use of model evaluations to compute sensitivity indices

Andrea Saltelli  

Computing the
indices
efficiently

Higher order Sobol' indices

Get access >

Art B. Owen , Josef Dick, Su Chen

Information and Inference: A Journal of the IMA, Volume 3, Issue 1, March 2014, Pages 59–81, <https://doi.org/10.1093/imaiai/iau001>

Published: 01 March 2014 **Article history** ▼

Plenty of code available in R, MATLAB, and Python



<https://cran.r-project.org/web/packages/sensitivity/sensitivity.pdf>

<https://cran.rstudio.com/web/packages/sensobol/index.html>



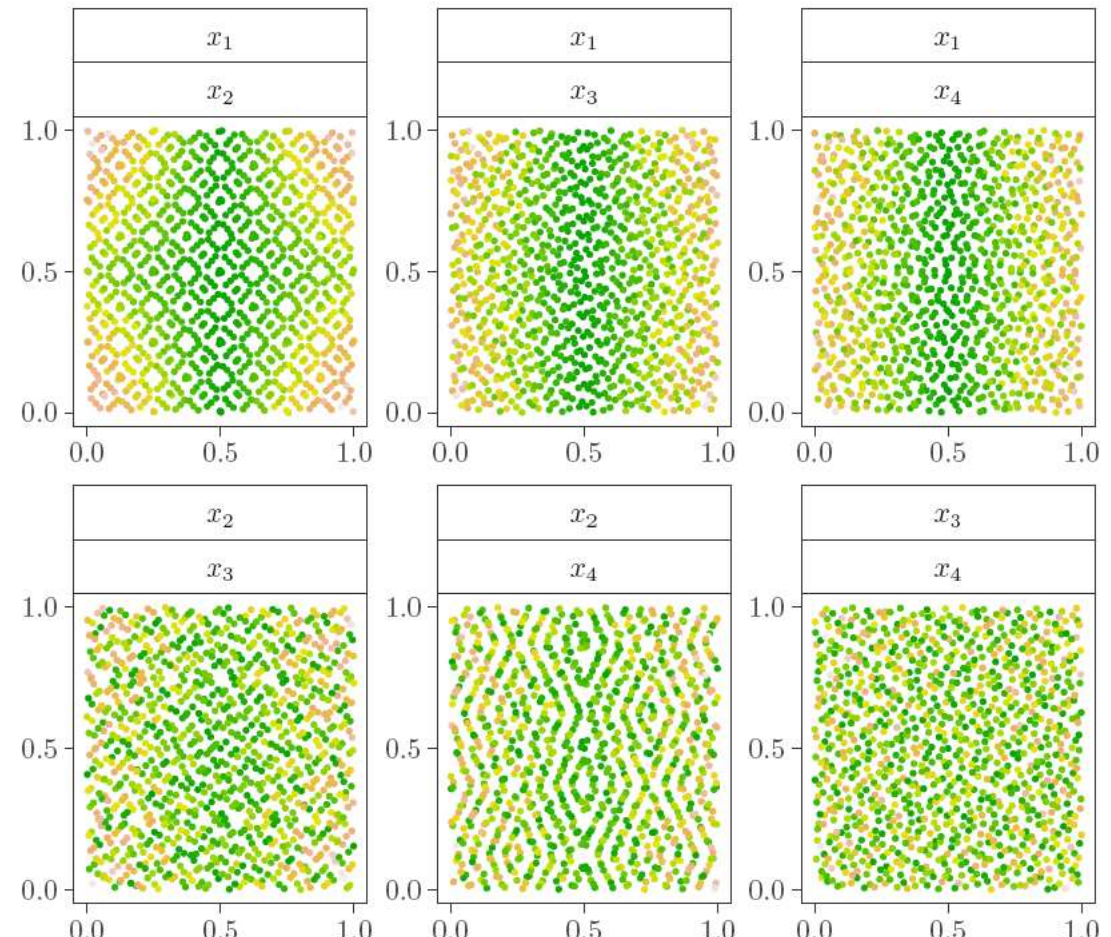
<https://www.uqlab.com/> (in MatLab, by Bruno Sudret and his team)



SALib <https://salib.readthedocs.io/en/latest/>

sensobol: An R Package to Compute Variance-Based Sensitivity Indices

Arnald Puy , Samuele Lo Piano , Andrea Saltelli , Simon A. Levin 



Model's effective dimension



ACADEMIC
PRESS

Available at
WWW.MATHEMATICSWEB.ORG
POWERED BY SCIENCE @ DIRECT•

Journal of Complexity 19 (2003) 101–124

Journal of
COMPLEXITY

<http://www.elsevier.com/locate/jco>

The effective dimension and quasi-Monte Carlo integration[☆]

Xiaoqun Wang^{a,b,*} and Kai-Tai Fang^c

^a*Department of Mathematical Sciences, Tsinghua University, Beijing 100084, China*

^b*School of Mathematics, University of New South Wales, Sydney 2052, Australia*

^c*Department of Mathematics, Hong Kong Baptist University, Hong Kong, China*

Received 12 February 2002; accepted 6 November 2002

The difficulty of a function/model is not in its number of dimensions but in the number of effective dimensions, either in the **truncation** or **superposition** sense

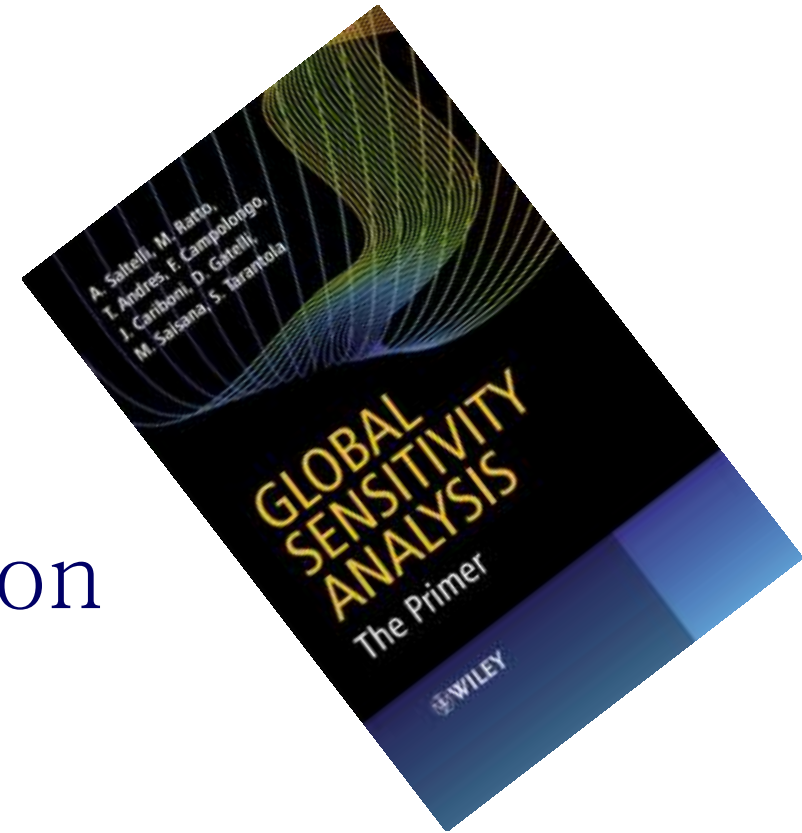
truncation sense = how many factors are important?

superposition sense=how high is the highest interaction?

Why using variance-based
sensitivity analysis methods

Advantages with variance based methods:

- graphic interpretation scatterplots
- statistical interpretation
- expressed plain English (another lesson)
- working with sets (another lesson)
- relation to settings such as factor fixing and factor prioritization
- give the effective dimension



Chapter 1 its
exercises

... anyone developing a
new method tests it against S_i, T_i



Water Resources Research

RESEARCH ARTICLE

10.1002/2015WR017558

Companion to
Razavi and Gupta [2016],
doi:10.1002/2015WR017559.

Key Points:

- The VARS framework enables

A new framework for comprehensive, robust, and efficient global sensitivity analysis: 1. Theory

Saman Razavi^{1,2} and Hoshin V. Gupta³

¹Global Institute for Water Security & School of Environment and Sustainability, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, ²Department of Civil and Geological Engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, ³Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona, USA

S_i, T_i can be used to do a sensitivity analysis of a sensitivity analysis...



Environmental Modelling & Software

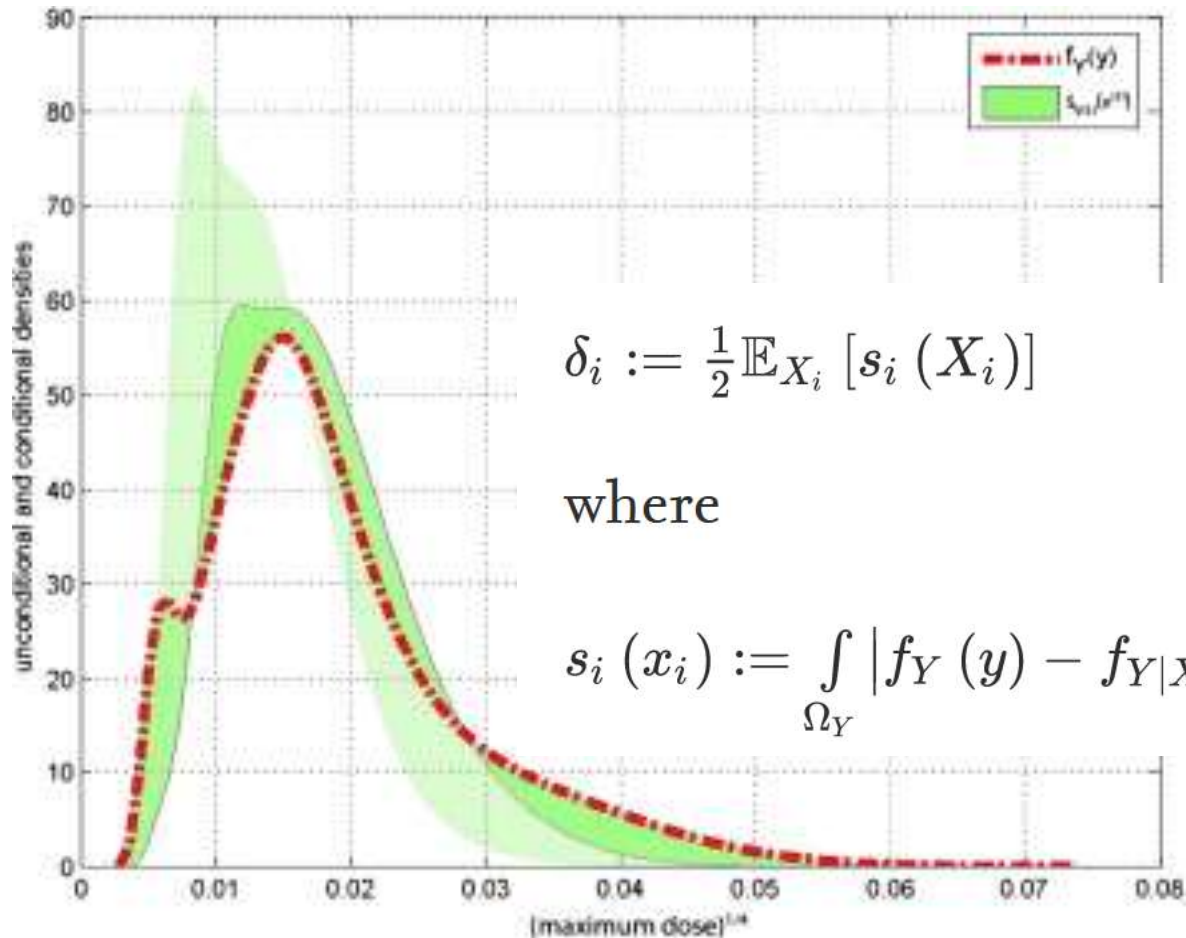
Volume 137, March 2021, 104960



Is VARS more intuitive and efficient than Sobol' indices?

Arnald Puy ^{a, b}  , Samuele Lo Piano ^c, Andrea Saltelli ^d

... but there are other methods that can be used for different settings, e.g. moment independent methods, Shapley coefficients, reduced spaces, VARS ...



Environmental Modelling & Software

Volume 34, June 2012, Pages 105-115



Model emulation and moment-independent sensitivity analysis: An application to environmental modelling

E. Borgonovo ^a, W. Castaings ^{b, c}, S. Tarantola ^d  

Don't use One factor At a
Time (OAT)

A geometric proof



Contents lists available at ScienceDirect

Environmental Modelling & Software

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

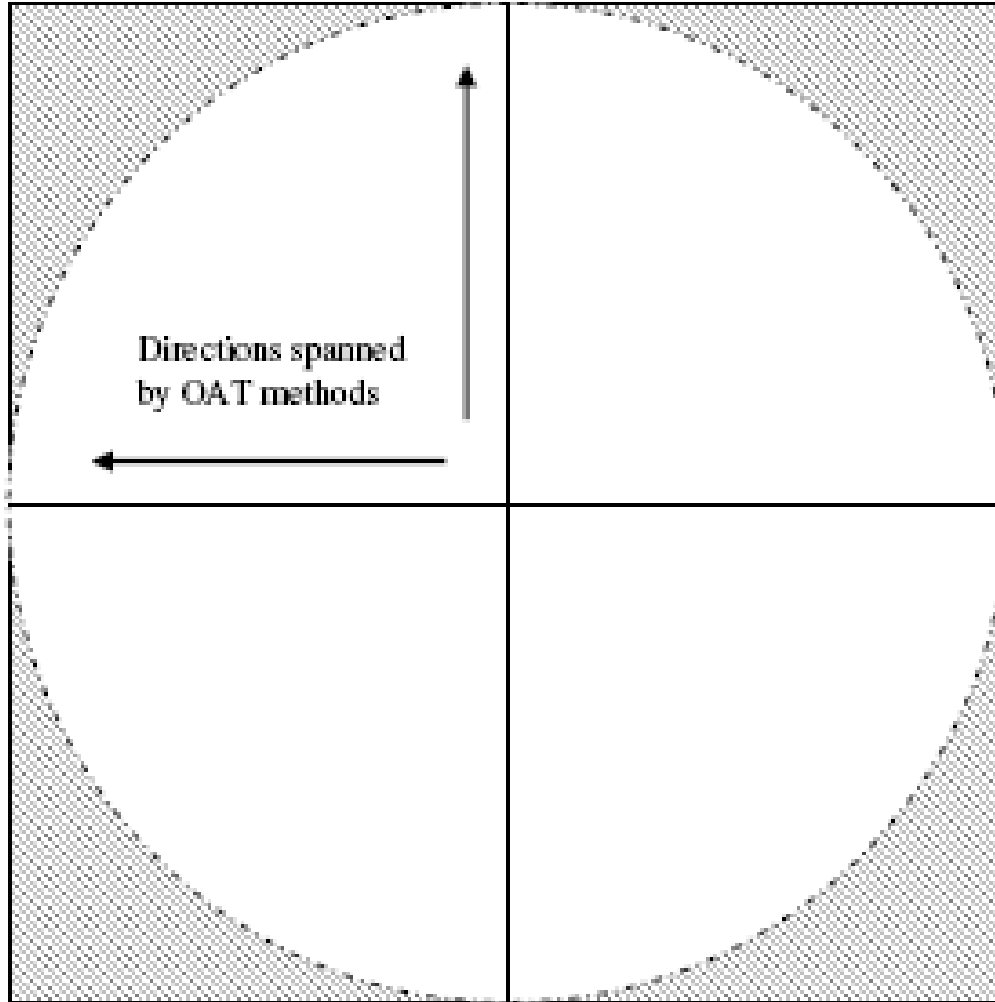


How to avoid a **perfunctory** sensitivity analysis

Andrea Saltelli*, Paola Annoni

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

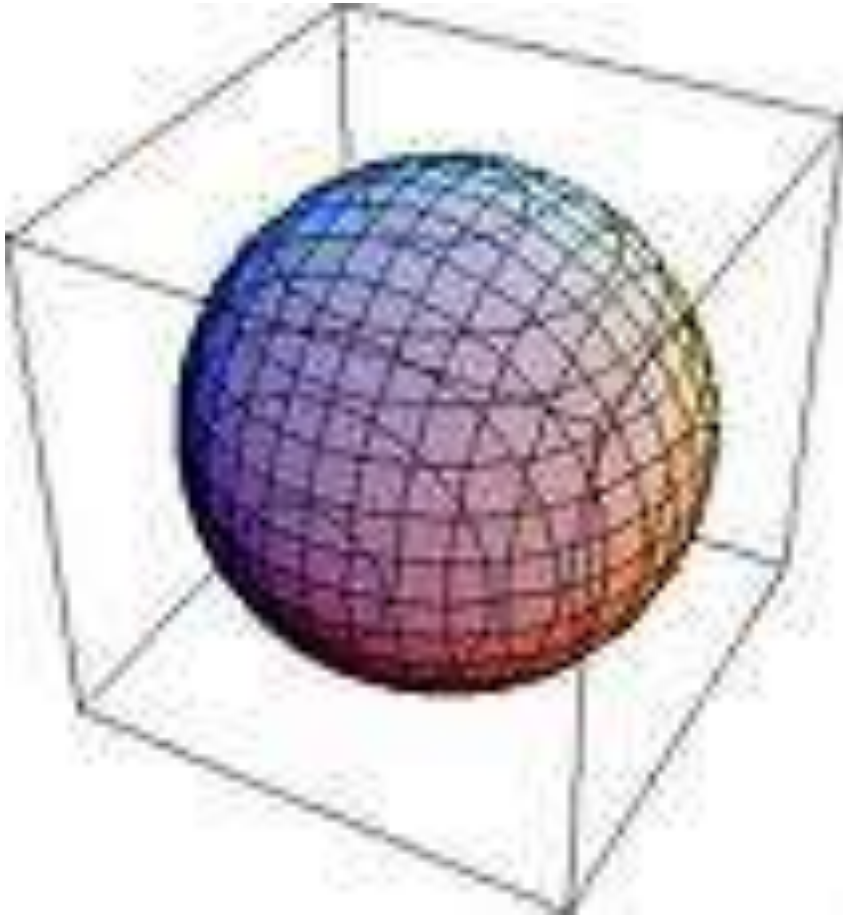
OAT in 2 dimensions



Area circle
/ area
square = ?

~ 3/4

OAT in 3 dimensions



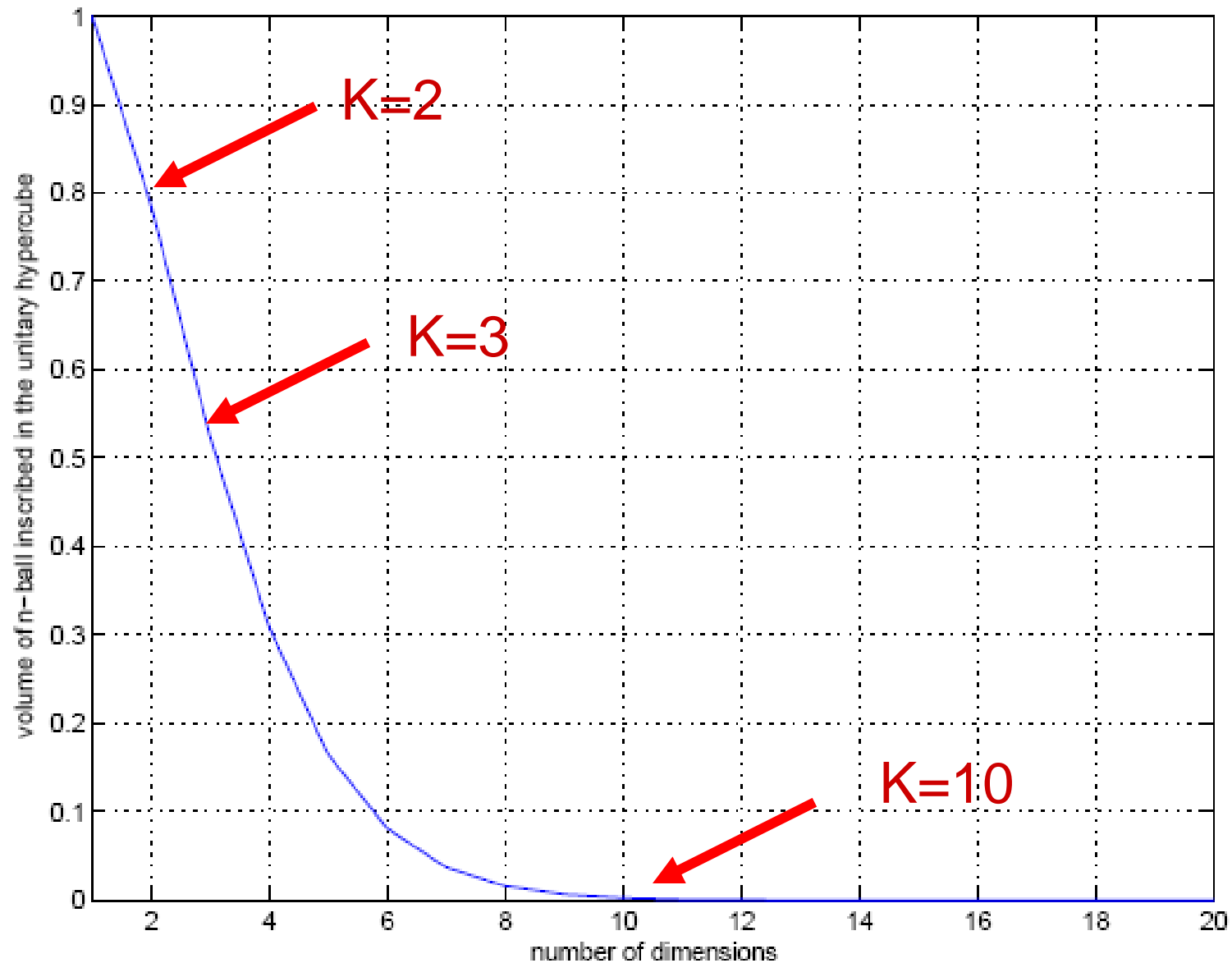
Volume sphere /
volume cube = ?

$\sim 1/2$

OAT in 10 dimensions; Volume
hypersphere / volume ten dimensional
hypercube =? ~ 0.0025



OAT in k dimensions



OAT does not capture interactions

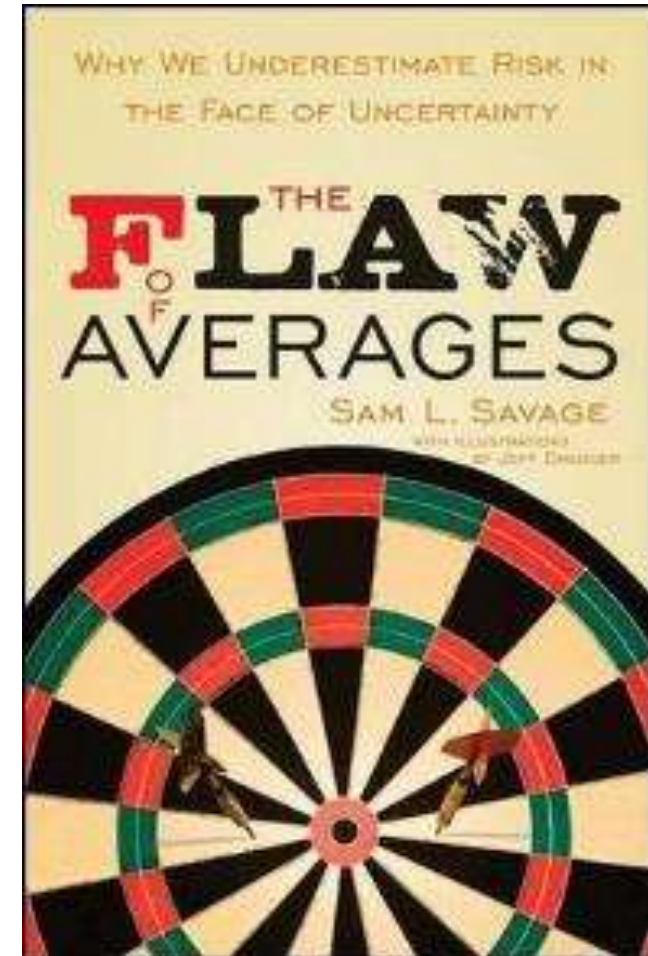
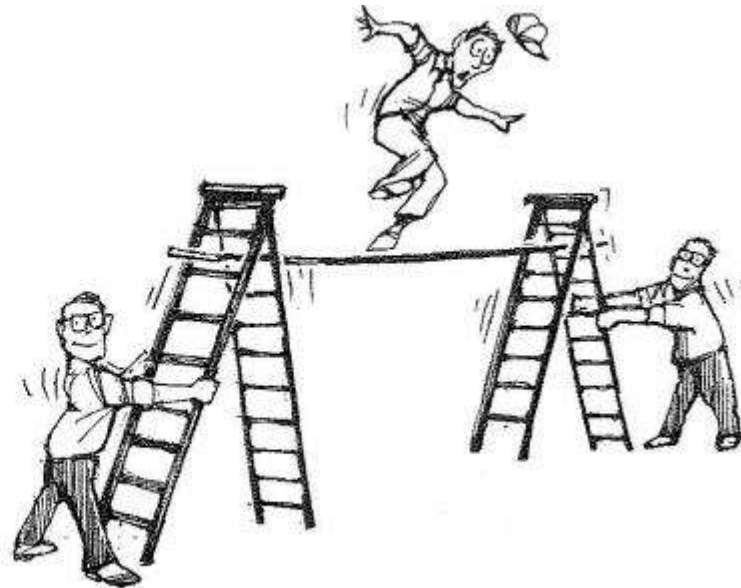
➔ The resulting analysis is non conservative

How would you test the scaffolding?

How coupled ladders are shaken in most of available literature



How to shake coupled ladders







Environmental Modelling & Software

Volume 114, April 2019, Pages 29-39



Why so many published sensitivity analyses are false: A systematic review of sensitivity analysis practices

Andrea Saltelli ^{a, b}  , Ksenia Aleksankina ^c, William Becker ^d, Pamela Fennell ^e, Federico Ferretti ^d, Niels Holst ^f, Sushan Li ^g, Qiongli Wu ^h

Don't use method that are
not model-independent
(such as PCC, PRCC)

Use model-free methods

Why not using correlation-regression based techniques?

PCC, PRCC, SRC, SRRC



Reliability Engineering & System Safety

Volume 28, Issue 2, 1990, Pages 229-253



Non-parametric statistics in sensitivity analysis for model output: A comparison of selected techniques

A. Saltelli, J. Marivoet



Computational Statistics & Data Analysis

Volume 13, Issue 1, January 1992, Pages 73-94



Sensitivity analysis for model output: Performance of black box techniques on three international benchmark exercises

A. Saltelli, T. Homma

➔ They assume linearity (PCC) or monotonicity (PRCC), which is difficult to know *ex-ante*

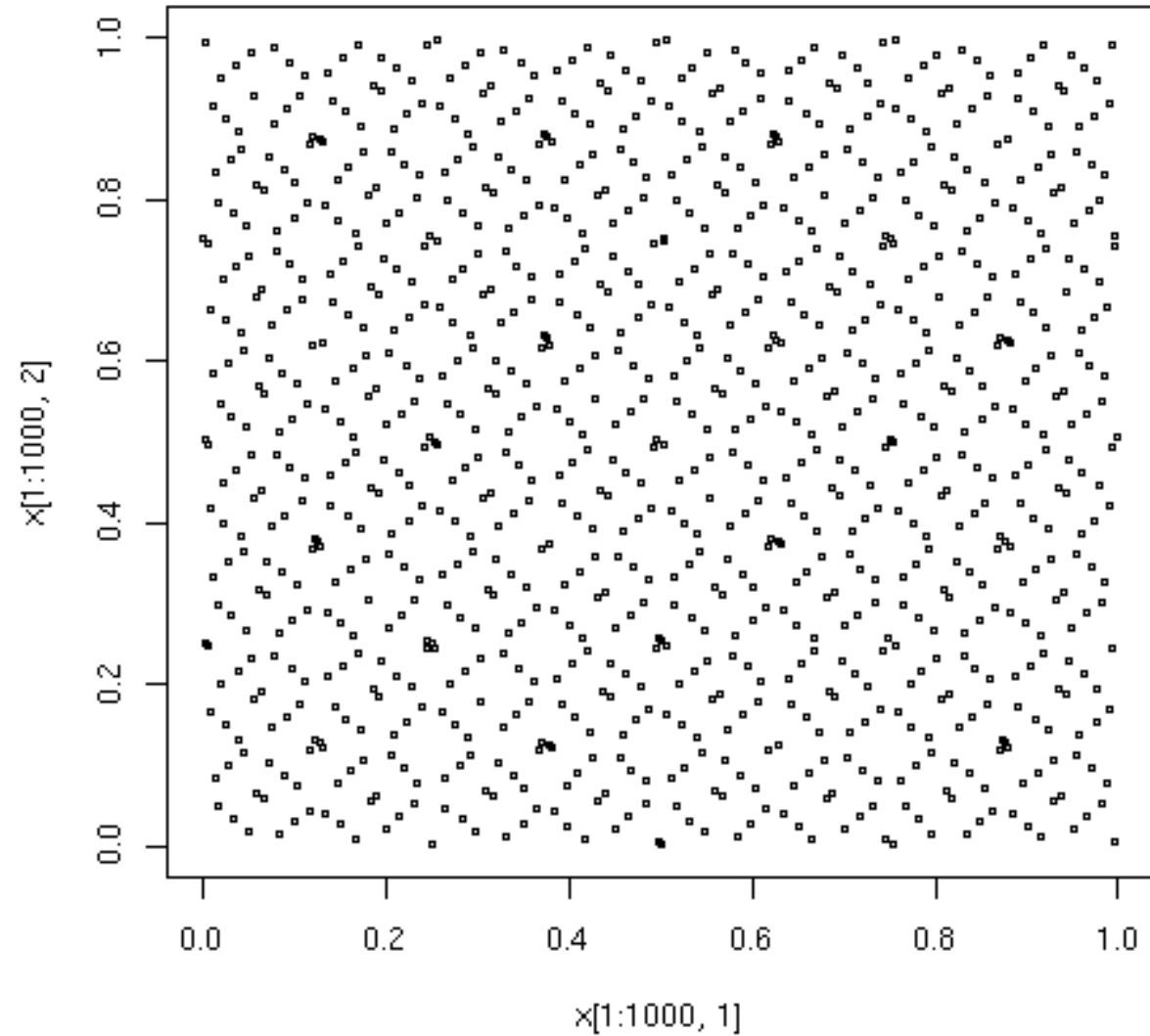
Don't use either LHS or
optimized LHS

Quasi-random sequences perform better

Quasi random sequences



Ilya M. Sobol'

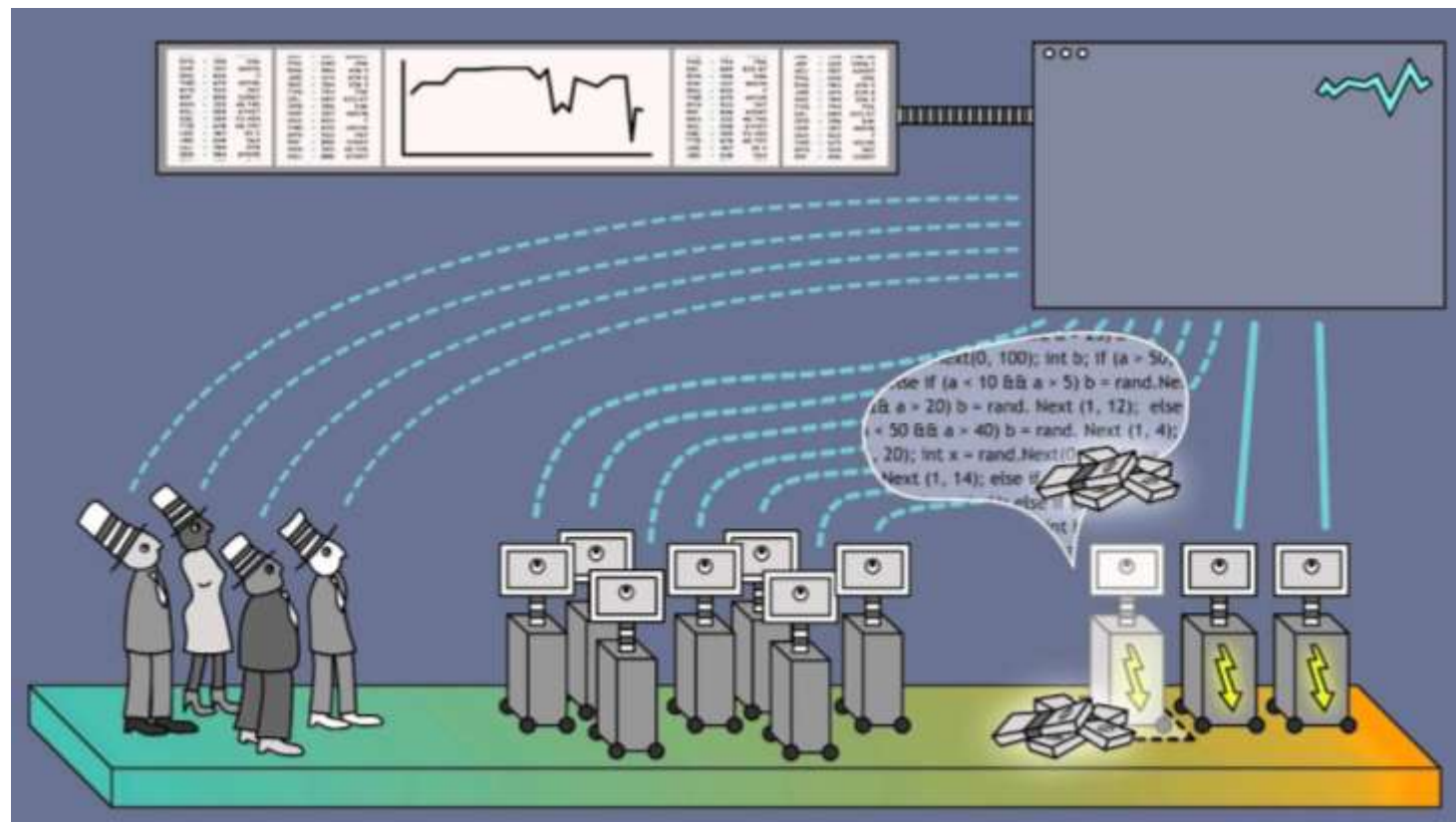


[Submitted on 10 May 2015]

Exploring multi-dimensional spaces: a Comparison of Latin Hypercube and Quasi Monte Carlo Sampling Techniques

Sergei Kucherenko, Daniel Albrecht, Andrea Saltelli

Sobol' LP-TAU
are used in high
frequency trading



Source: <https://www.youtube.com/watch?v=z4nCTdQIH8w>

Don't run the model just once

There is much to learn by running the model a few times, especially during model building

Lubarsky's Law of Cybernetic Entomology:
there is always one more bug!



Model routinely used to produce point estimates may becomes non conservative when the uncertainty is plugged in

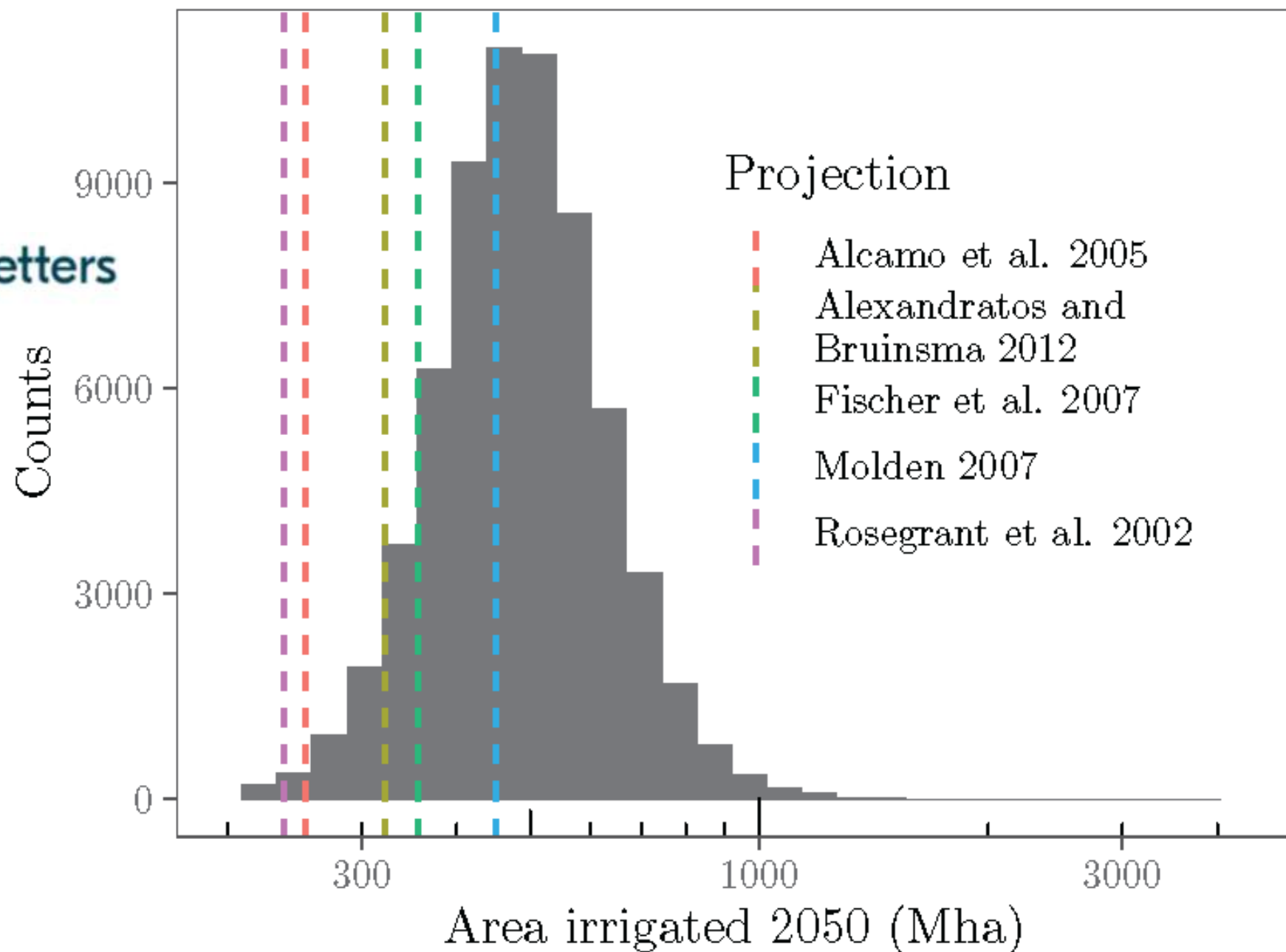
Current Models Underestimate Future Irrigated Areas

Geophysical Research Letters

A. Puy✉, S. Lo Piano, A. Saltelli

Citation:

Puy, A., Lo Piano, S., & Saltelli, A. (2020). Current models underestimate future irrigated areas. *Geophysical Research Letters*, 47, e2020GL087360. <https://doi.org/10.1029/2020GL087360>



The delusive accuracy of global irrigation water withdrawal estimates

Miscalculating the volumes of water withdrawn for irrigation, the largest consumer of freshwater in the world, jeopardizes sustainable water management. Hydrological models quantify water withdrawals, but their estimates are unduly precise. Model imperfections need to be appreciated to avoid policy misjudgements.

Sustainable Development Goals (SDGs), from Zero Hunger (SDG 2) to Water Stress (SDG 6), will be poorly assessed if irrigation water withdrawal convey an illusion of accuracy


nature communications

[Explore content](#) ▾ [About the journal](#) ▾ [Publish with us](#) ▾

[nature](#) > [nature communications](#) > [comment](#) > article

[Comment](#) | [Open Access](#) | [Published: 08 June 2022](#)

The delusive accuracy of global irrigation water withdrawal estimates

[Arnald Puy](#) , [Razi Sheikholeslami](#), [Hoshin V. Gupta](#), [Jim W. Hall](#), [Bruce Lankford](#), [Samuele Lo Piano](#), [Jonas Meier](#), [Florian Pappenberger](#), [Amilcare Porporato](#), [Giulia Vico](#) & [Andrea Saltelli](#)

Solution? Modelling of the
modelling process



Jorge Luis Borges
(1899–1986)



Ts'ui Pên
(character of the novel)

The garden of forking paths: Why multiple comparisons can be a problem, even when there is no “fishing expedition” or “p-hacking” and the research hypothesis was posited ahead of time*

Andrew Gelman[†] and Eric Loken[‡]

14 Nov 2013

The garden of forking paths: Why multiple comparisons can be a problem, even when there is no “fishing expedition” or “p-hacking” and the research hypothesis was posited ahead of time*

Andrew Gelman[†] and Eric Loken[‡]

14 Nov 2013

Why this matters?



PNAS

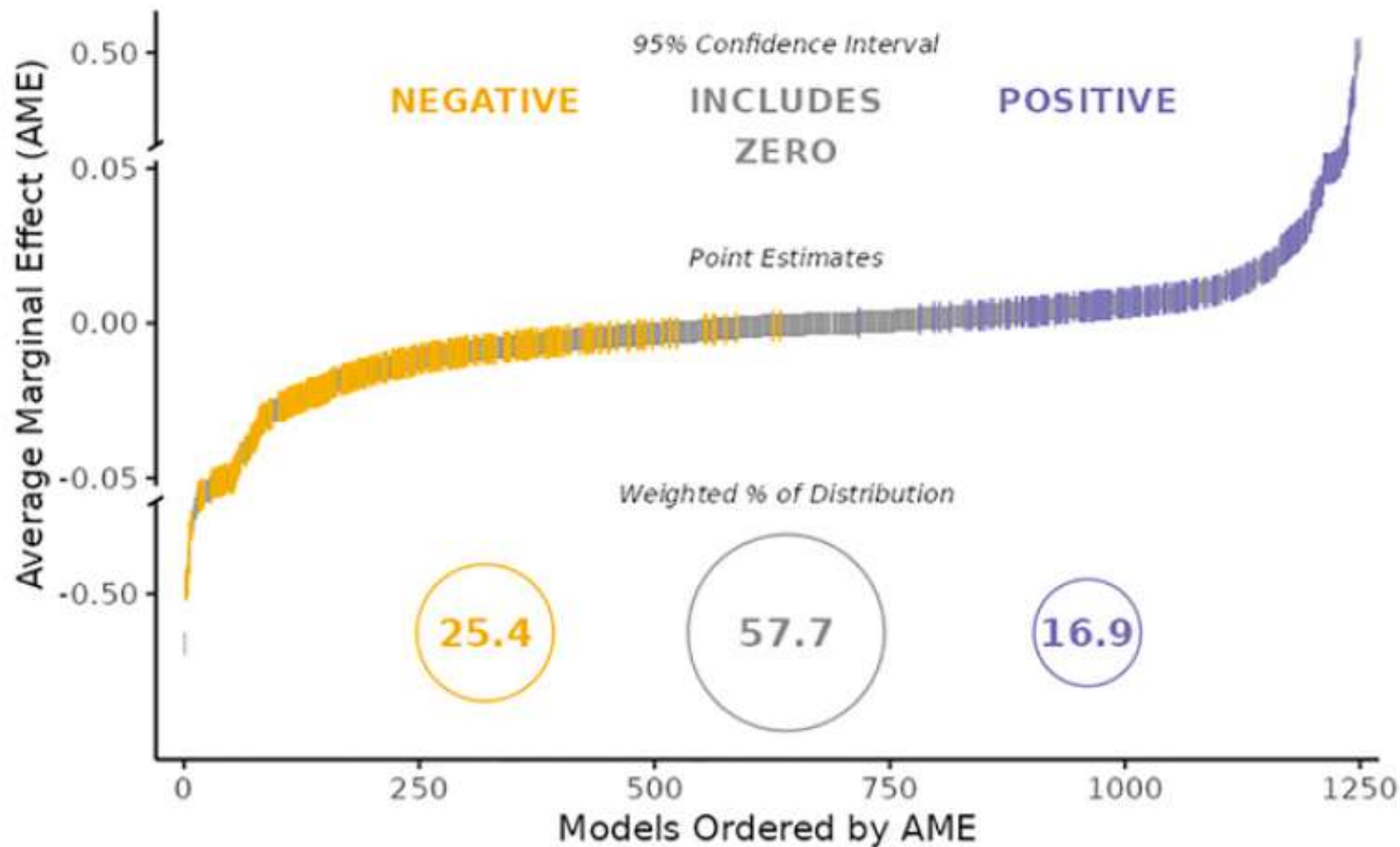
RESEARCH ARTICLE

SOCIAL SCIENCES

 OPEN

Observing many researchers using the same data and hypothesis reveals a hidden universe of uncertainty

Edited by Douglas Massey, Princeton University, Princeton, NJ; received March 6, 2022; accepted August 22, 2022



“Will different researchers [73 teams] converge on similar findings when analyzing the same data?

...

...teams’ results varied greatly, ranging from large negative to large positive effects”

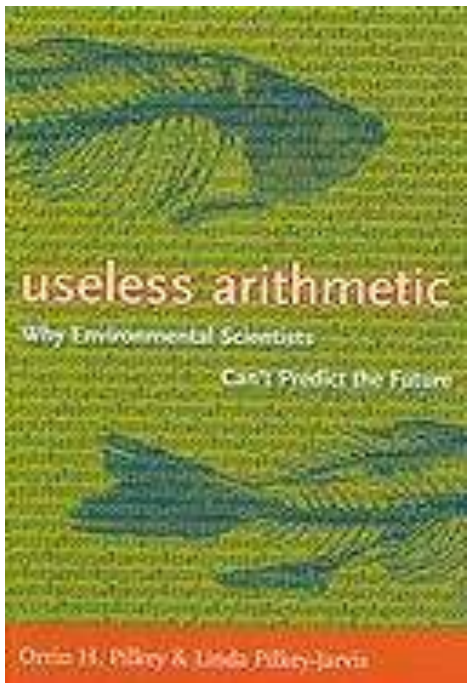
(Massey et al. 2022)

Don't confuse the map with
the territory

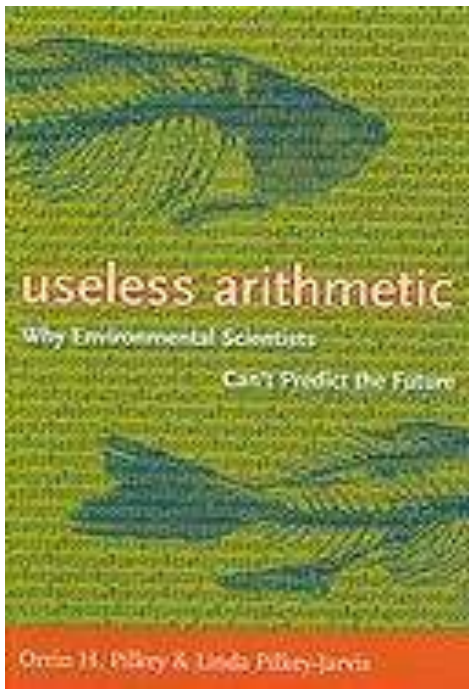
If you do, sensitivity analysis will not save you



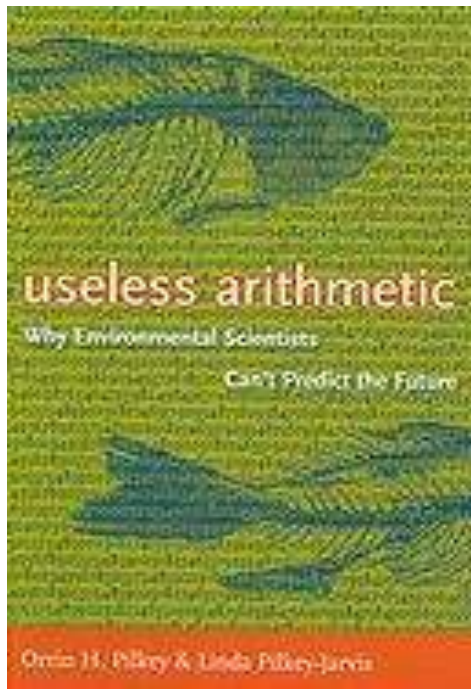
Orrin H.
Pilkey



Useless Arithmetic: Why Environmental Scientists Can't Predict the Future
by Orrin H. Pilkey and Linda Pilkey-Jarvis, Columbia University Press,
2009.



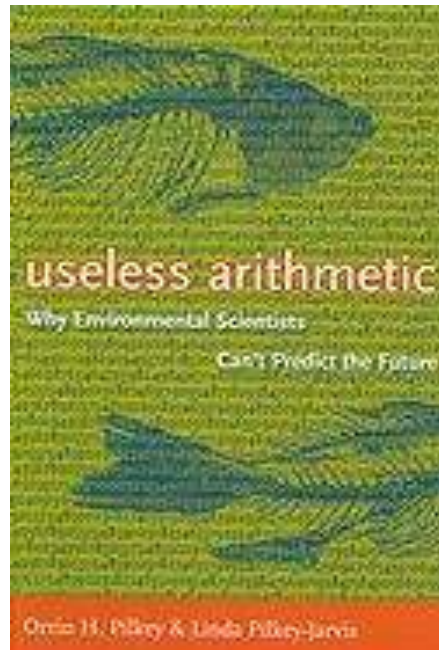
<<It is important, however, to recognize that the sensitivity of the parameter in the equation is what is being determined, not the sensitivity of the parameter in nature>>

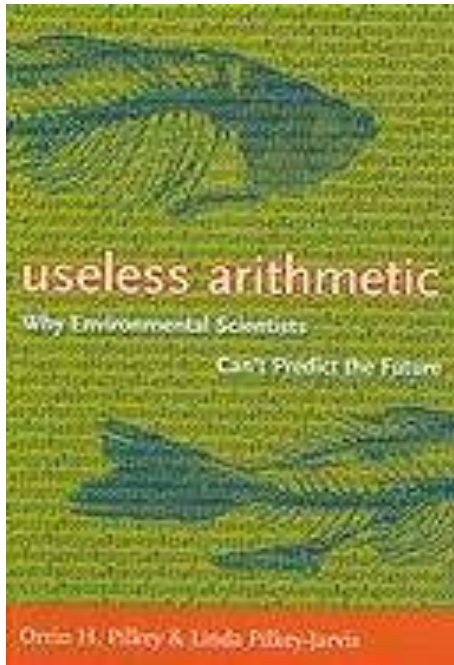


<<...If the model is wrong or if it is a poor representation of reality, determining the sensitivity of an individual parameter in the model is a meaningless pursuit>>

One of the examples discussed concerns the **Yucca Mountain** repository for radioactive waste. TSPA model (for total system performance assessment) for safety analysis.

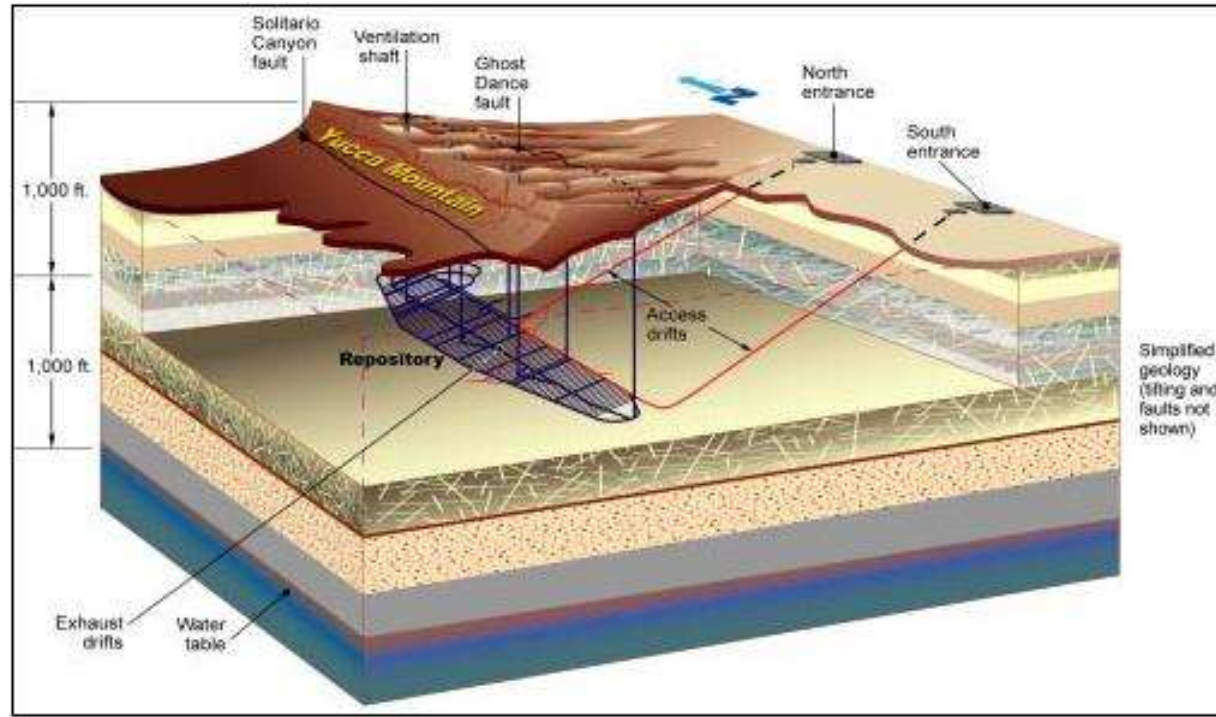
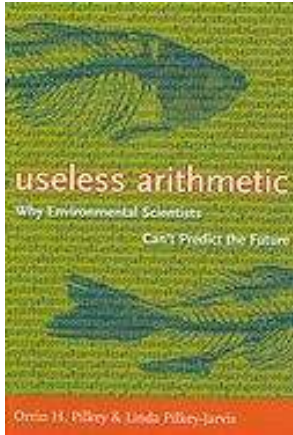
TSPA is Composed of 286 sub-models.





TSPA (like any other model) **relies on assumptions** → one is the low permeability of the geological formation → long time for the water to percolate from surface to disposal.



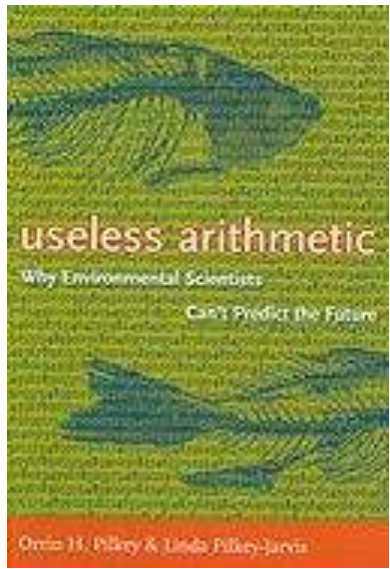


The confidence of the stakeholders in TSPA was not helped when evidence was produced which could lead to an upward revision of 4 orders of magnitude of this parameter
(the ^{36}Cl story)

Type III error in sensitivity: Examples:

In the case of TSPA (Yucca mountain) a range of 0.02 to 1 millimetre per year was used for percolation of flux rate.

→... SA useless if it is instead ~ 3,000 millimetres per year.



“Scientific mathematical modelling should involve constant efforts to falsify the model”

→ Organized skepticism (as per CUDOS)

Communalism, Universalism, Disinterestedness, Organized Skepticism, from sociology of science, Robert K. Merton.



Steve Rayner

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 to deal with
“uncomfortable knowledge”.

Denial, Dismissal, Diversion, Displacement



Model based

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

Displacement: “The model we have developed tells us that real progress is being achieved” (The focus is now the model not the problem).

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

Example of displacement: Chesapeake Bay Program (CBP) modelling work

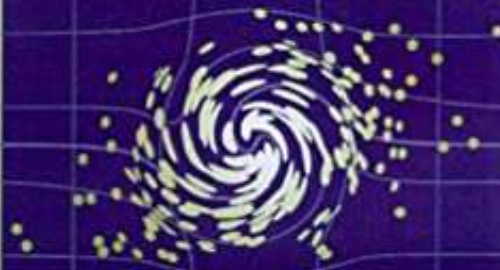
“Bay models are used to track nutrient loads to ensure the cap is not exceeded”

➔ The model results – rather than the actual measurements, become the substance of use

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

PREDICTION

Science, Decision Making,



and the Future of Nature

Edited by Daniel Sarewitz,
Roger A. Pielke, Jr., and Radford Byerly

Model GENESIS for beach
erosion



**US Army Corps
of Engineers®**

Manipulated to support coastal-engineering
projects

It neglected the role of extreme event

Sarewitz, D., Pielke, R. A. & Byerly, R. *Prediction: Science, Decision Making, and the Future of Nature* (Island Press, 2000).

Beware the size of your
model

Mind the conjecture of O'Neil



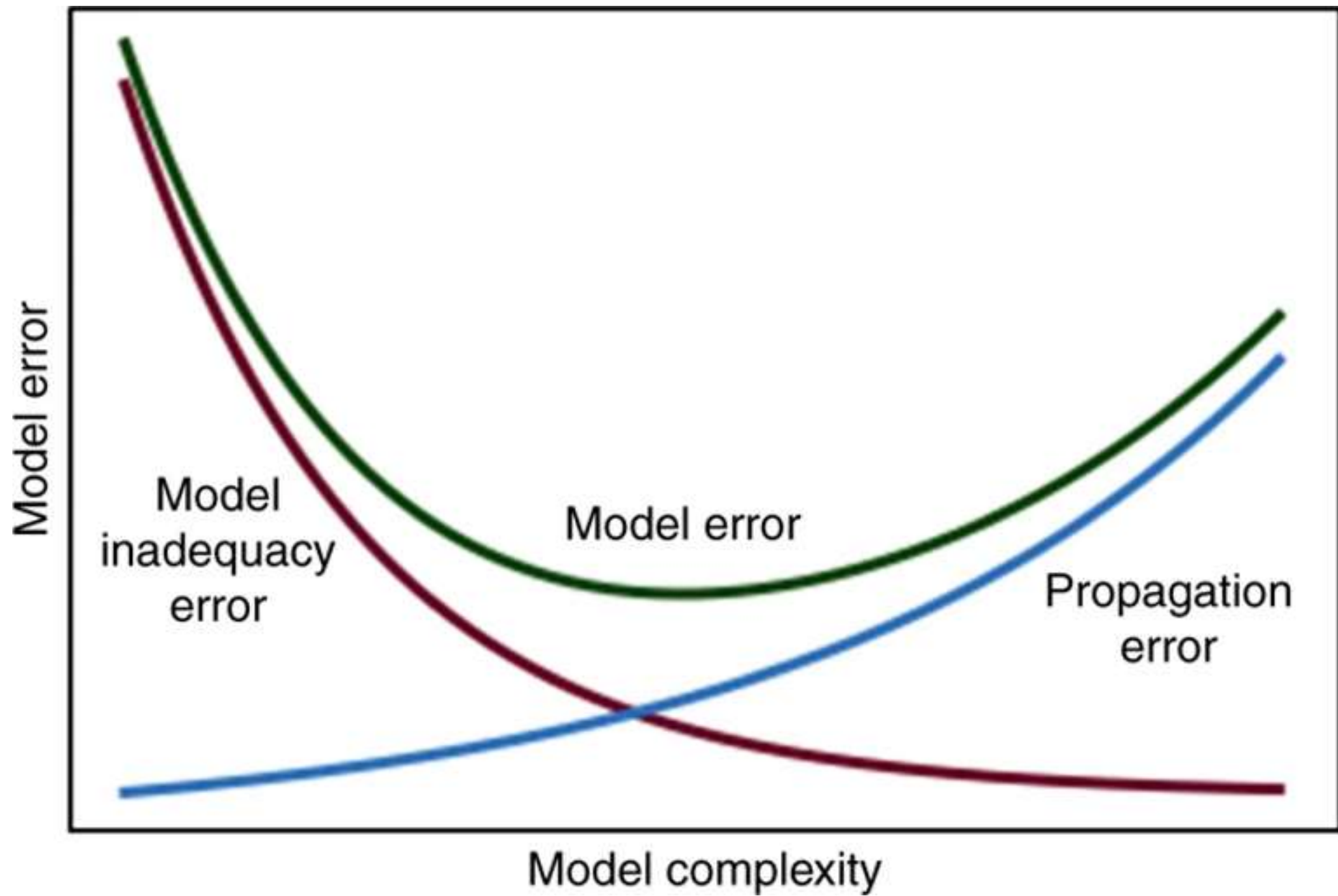
Comment

Open Access

Published: 27 August 2019

A short comment on statistical versus mathematical modelling

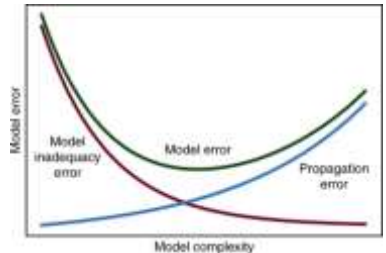
Andrea Saltelli 



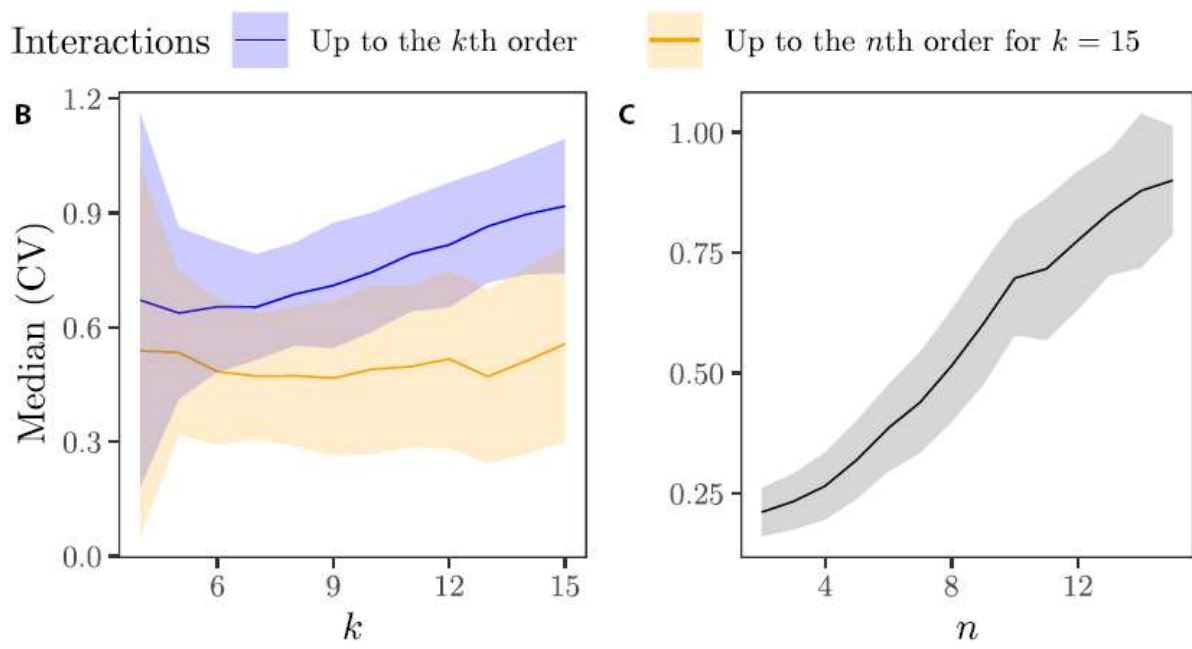
Models with higher effective dimensions tend to produce more uncertain estimates

ARNALD PUY, PIERFRANCESCO BENEVENTANO, SIMON A. LEVIN, SAMUELE LO PIANO, TOMMASO PORTALURI, AND ANDREA SALTIELLI

SCIENCE ADVANCES • 19 Oct 2022 • Vol 8, Issue 42 • DOI: 10.1126/sciadv.abn9450



Empirical test using the SA-based concept of effective dimension



Conjecture by O'Neill, also known as Zadeh's principle of incompatibility, whereby as complexity increases "precision and significance (or relevance) become almost mutually exclusive characteristics"

In M. G. Turner and R. H. Gardner, "Introduction to Models" in *Landscape Ecology in Theory and Practice*, New York, NY: Springer New York, 2015, pp. 63–95.

L. Zadeh, "Outline of a New Approach to the Analysis of Complex Systems and Decision Processes," *IEEE Trans. Syst. Man. Cybern.*, vol. 3, no. 1, pp. 28–44, 1973.

“...the choice to go for a smaller amount of inputs should be supported with a broader global analysis first to avoid skipping important variables” (Mariia Kozlova)

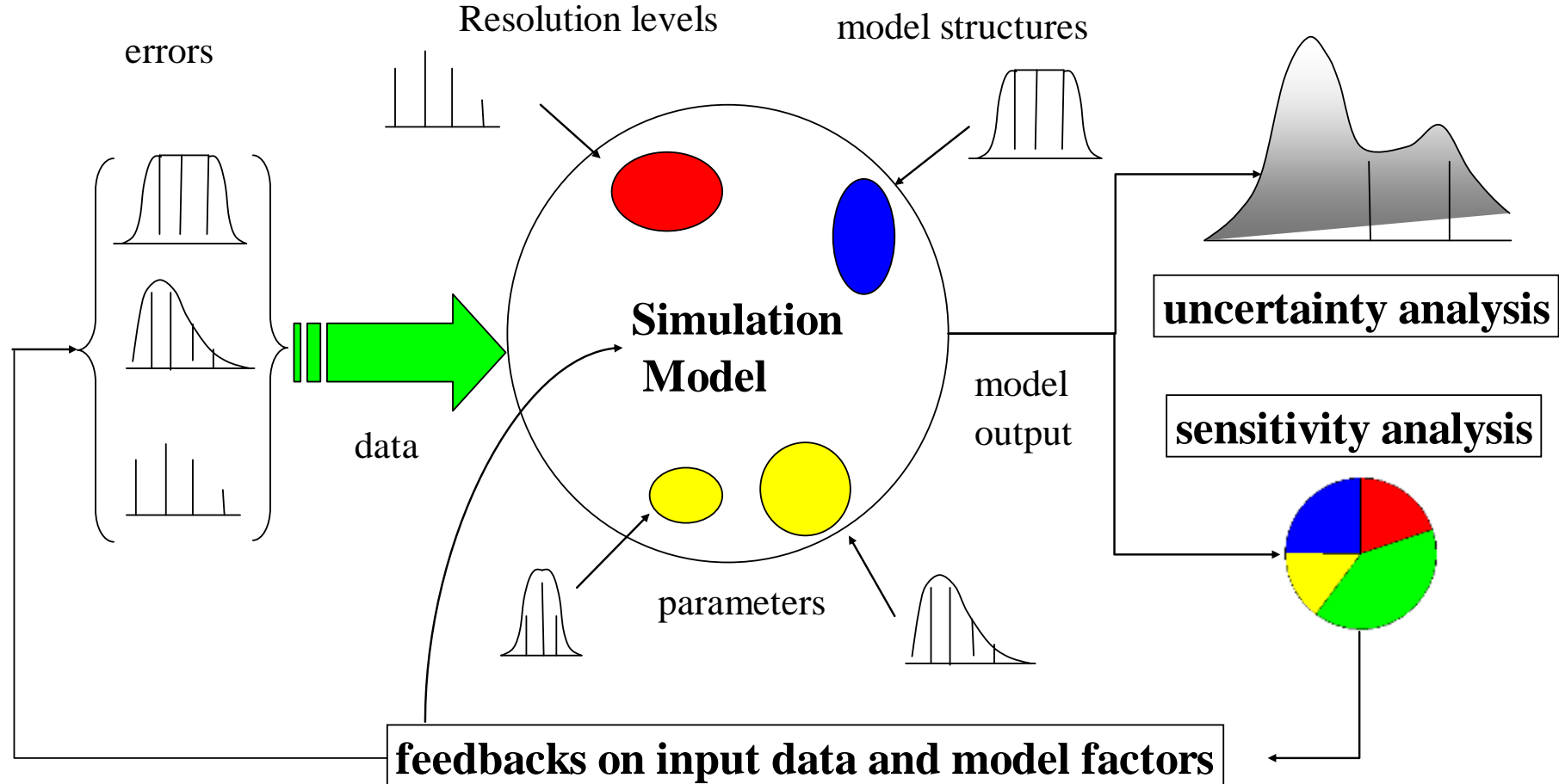


Don't sample just
parameters and boundary
conditions

Explore thoroughly the space of the
assumptions

Remember?

An engineer's vision of UA, SA

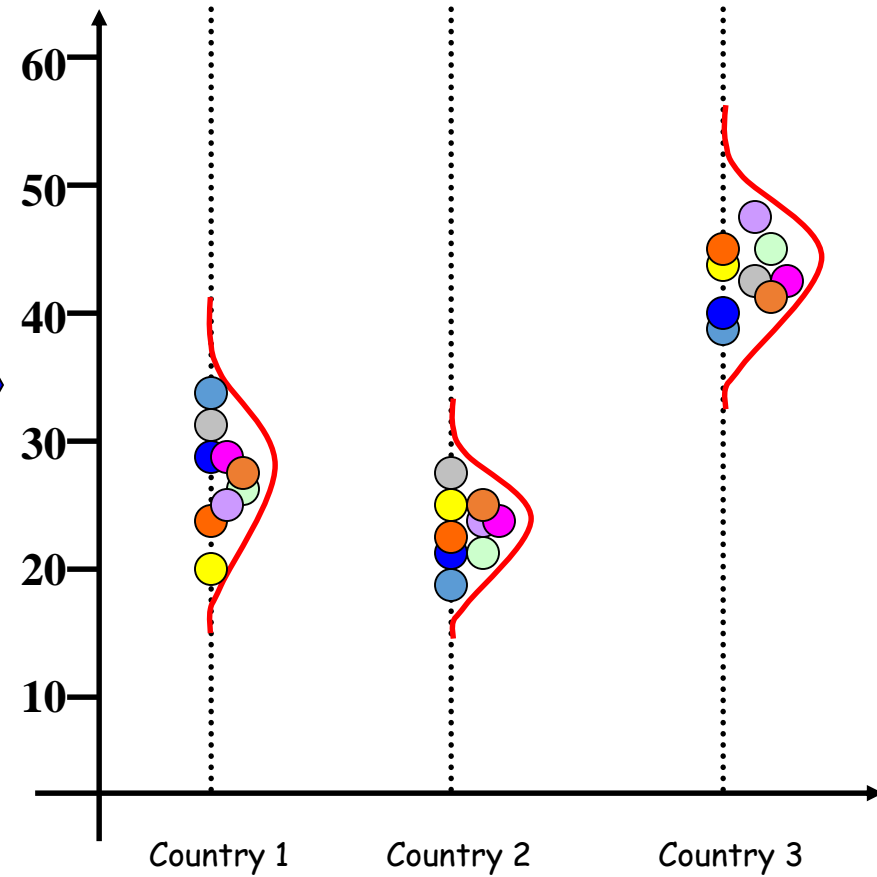
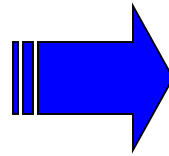
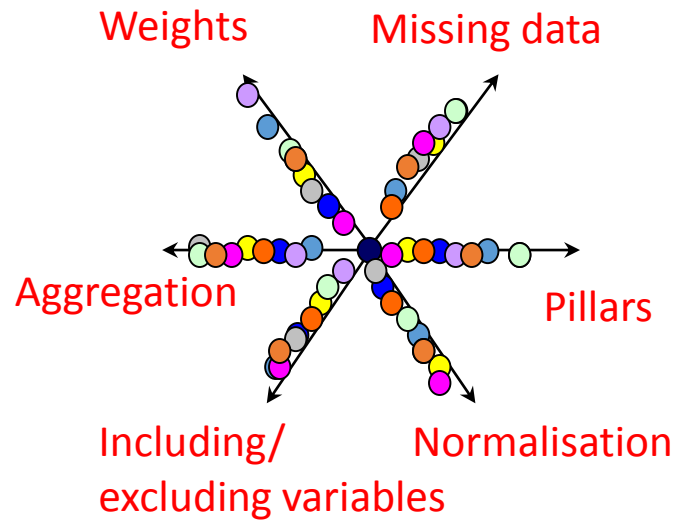


One can sample more than just factors:

- modelling assumptions,
- alternative data sets,
- resolution levels,
- scenarios ...

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



Don't go public
with your results
without having
seen your SA

Find SA before SA finds you

Try to Find God
before God Finds
You.

Global Environmental Change 20 (2010) 298–302



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

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



William Nordhaus,
University of Yale
Nobel 'Economics'
2018



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*

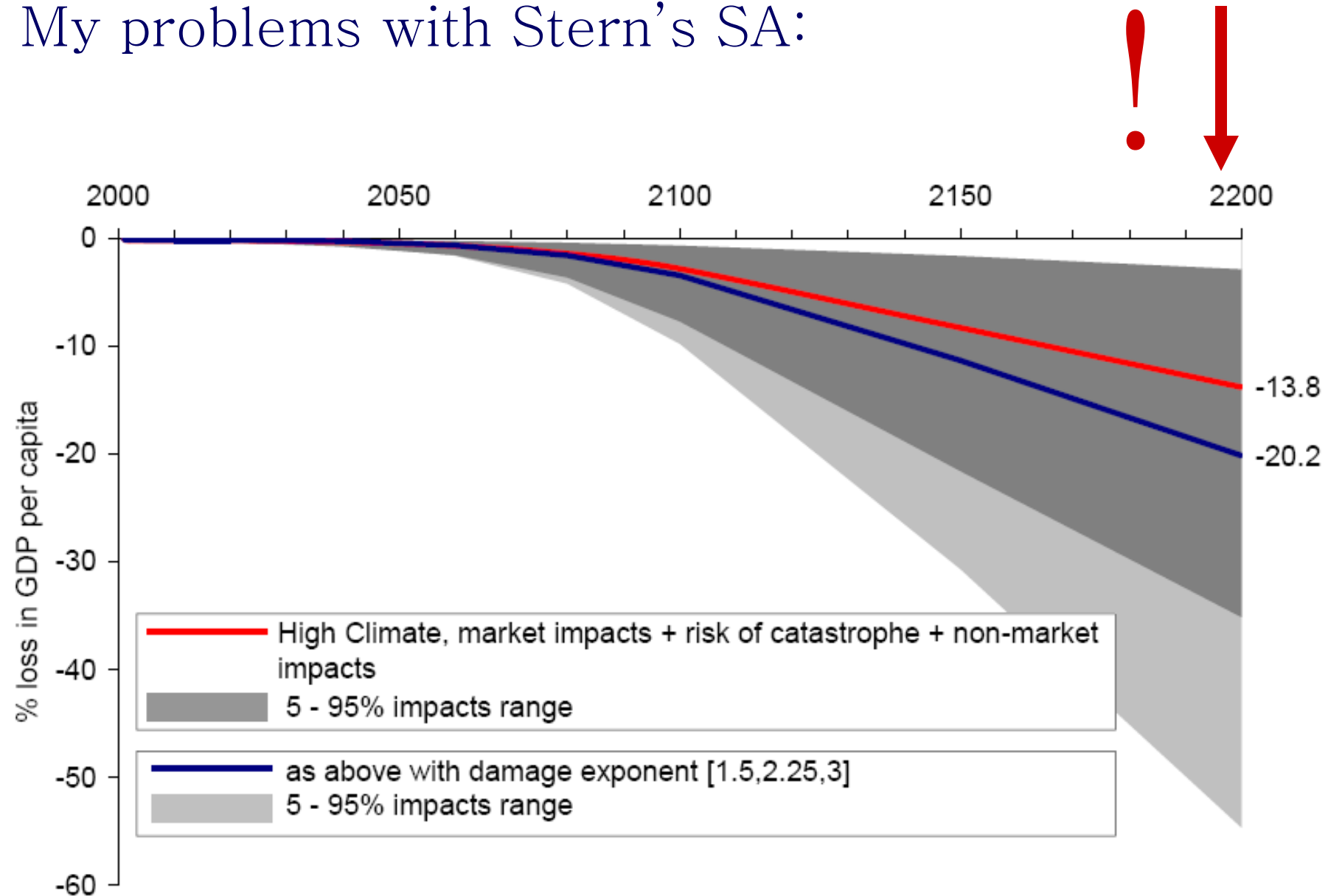


Nordhaus → attacks Stern based on ‘wrong’ range of discount rate (\sim you are GIGging)

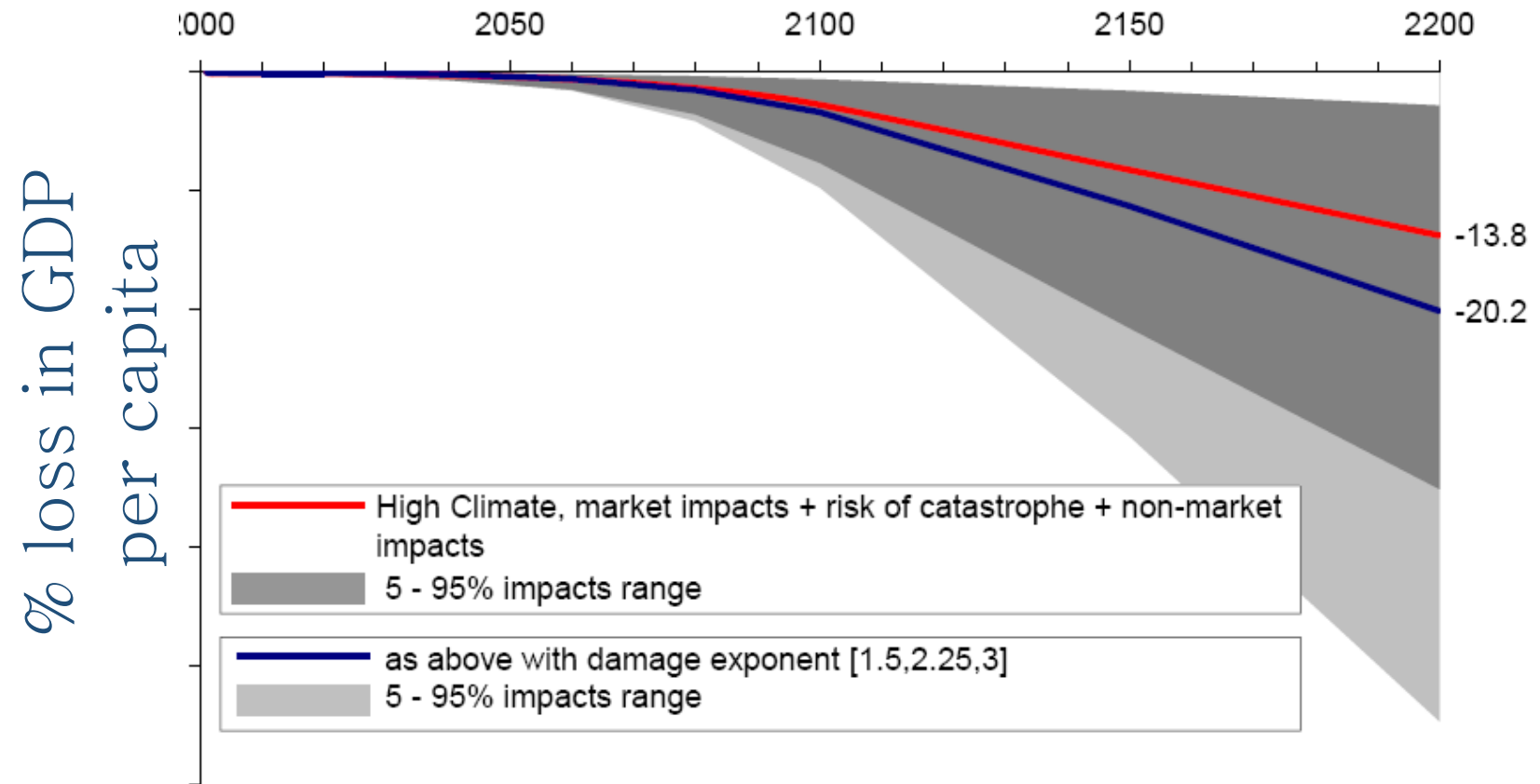


Stern → Perform a sensitivity analysis and retorts: ‘My analysis shows robustness’

My problems with Stern's SA:

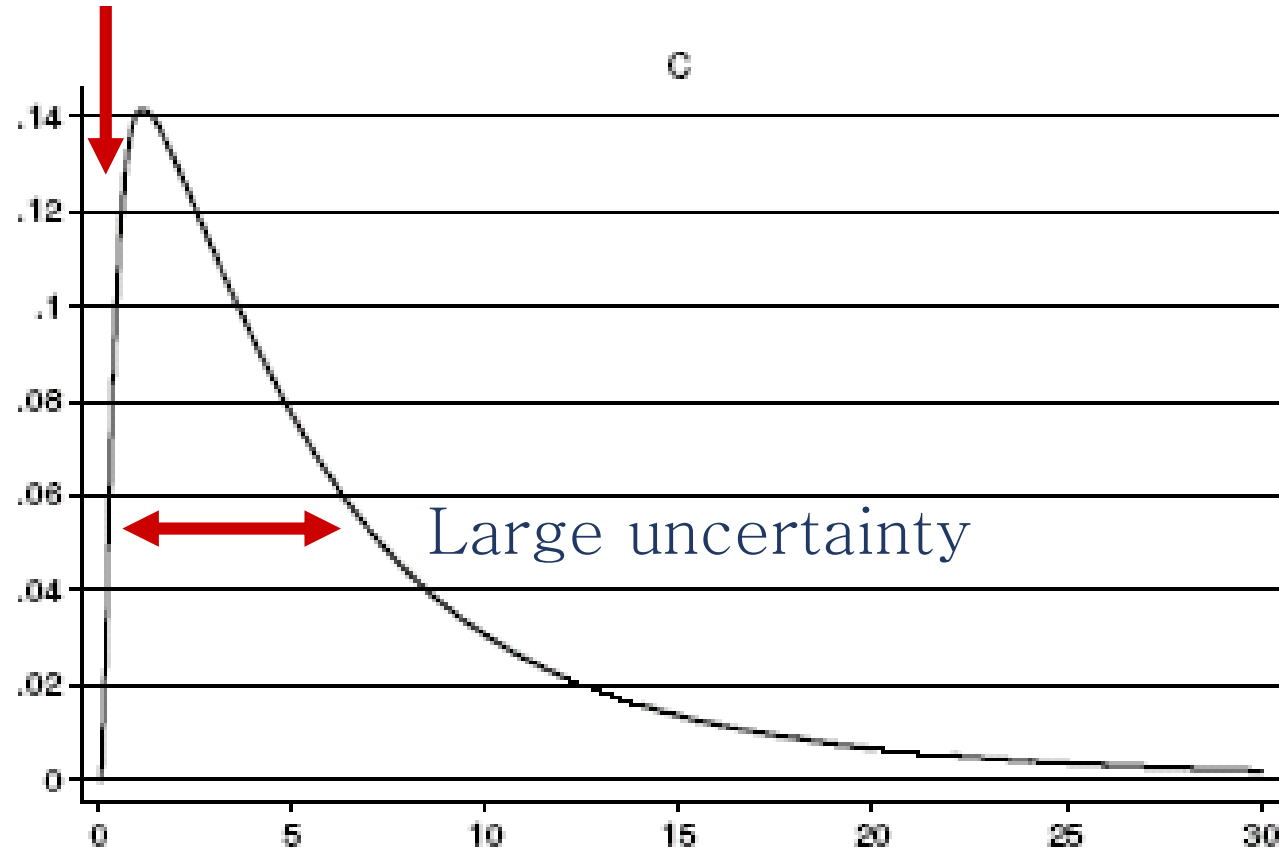


... but foremost Stern says:
changing assumptions → important effect
when instead he should admit that:
changing assumptions → all changes a lot



How was it done? A reverse engineering of the analysis

Missing points



% loss in GDP per capita

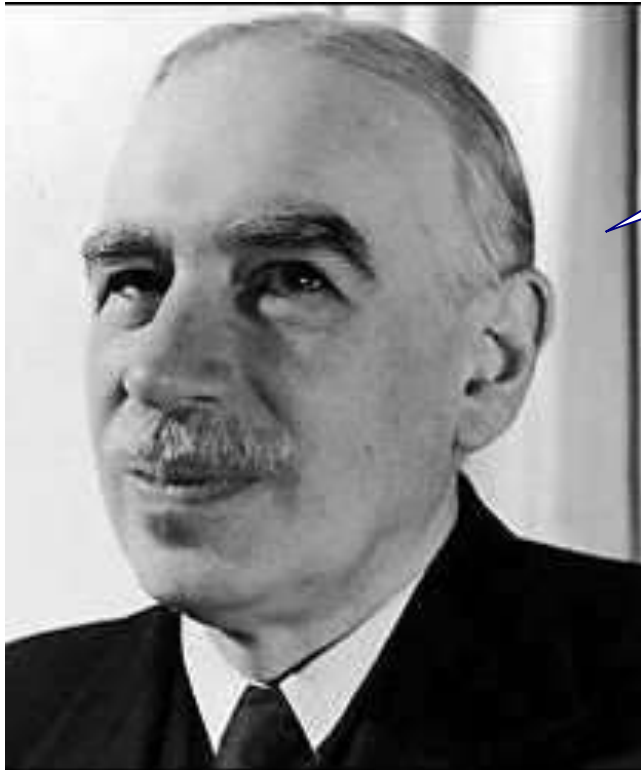
Conclusion:

Model prediction are too uncertain to adjudicate the dispute about the urgency of action on climate change;

Both assertion (Stern) and refutation (Nordhaus) are indefensible

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

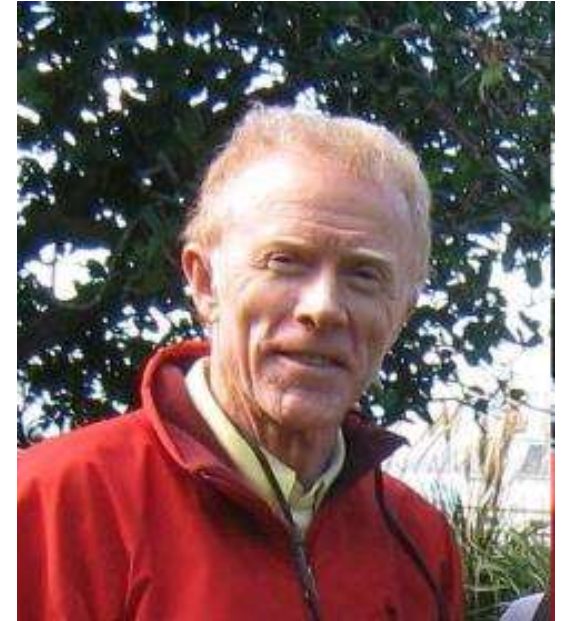
... precisely wrong



Peter Kennedy, A Guide to Econometrics.

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 “



NEVER vary all factors
of the same amount

Be it 5%, 10%, or 20%



New WHO estimates: Up to 190 000 people could die of COVID-19 in Africa if not controlled

07 May 2020

Brazzaville – Eighty-three thousand to 190 000 people in Africa could die of COVID-19 and 29 million to 44 million could get infected in the first year of the pandemic if containment measures fail, a new study by the World Health Organization (WHO) Regional Office for Africa finds. The research, which is based on prediction modelling, looks at 47 countries in the



Speculative scenario in which ten uncertain input probabilities are increased by an arbitrary 10% — as if they were truly equally uncertain — with no theoretical or empirical basis for such a choice



In a numerical experiment relating to a real-life application the range of uncertainty of each input is crucial input to the analysis, and often the most expensive to get

... beside uncertainty can be used instrumentally

Five ways to ensure that models serve society: a manifesto

Pandemic politics highlight how predictions need to be transparent and humble to invite insight, not blame.

>260 references
SUPPLEMENTARY INFORMATION
1. Additional information and references



Illustration by David Parkins



nature



nature

Andrea Saltelli , Gabriele Bammer, Isabelle Bruno, Erica Charters, Monica Di Fiore, Emmanuel Didier, Wendy Nelson Espeland, John Kay, Samuele Lo Piano, Deborah Mayo, Roger Pielke Jr, Tommaso Portaluri, Theodore M. Porter, Arnald Puy, Ismael Rafols, Jerome R. Ravetz, Erik Reinert, Daniel Sarewitz, Philip B. Stark, Andrew Stirling, Jeroen van der Sluijs & Paolo Vineis

3 modellers Lo Piano, Puy, Saltelli

2 experts models and society Pielke, van der Sluijs

3 statisticians Mayo, Stark, Portaluri

2 statactivistes Bruno, Didier

2 economists Kay, Raynert

1 epidemiologist Vineis

2 sociologists of quantification

Espeland, Porter

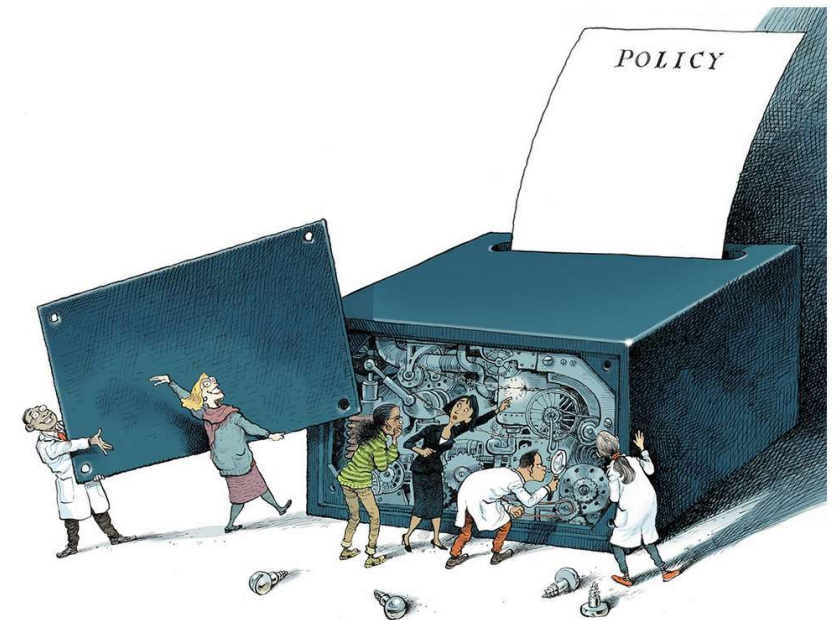
3 STS scholars Bammer, Sarewitz, Stirling

1 philosopher Ravetz

1 historian Charters

1 political scientists Di Fiore

1 expert RRI - Open Science Rafols



The End