Composite indicators

Andrea Saltelli

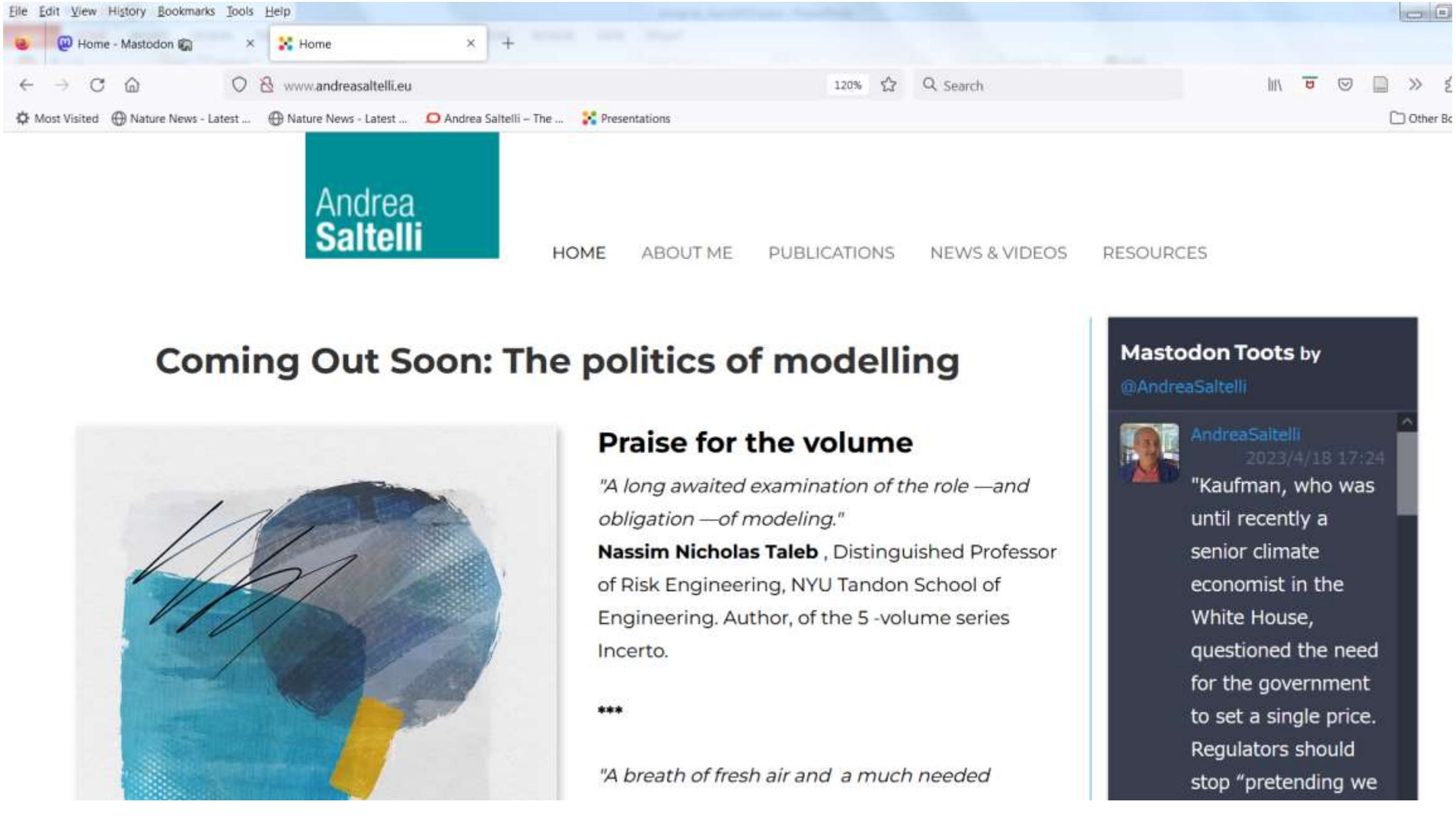
June 2023

Statistical Data Analysis Module A

&

Project **i4Driving**

Where to find this talk: www.andreasaltelli.eu



Composite indicators: What are they?

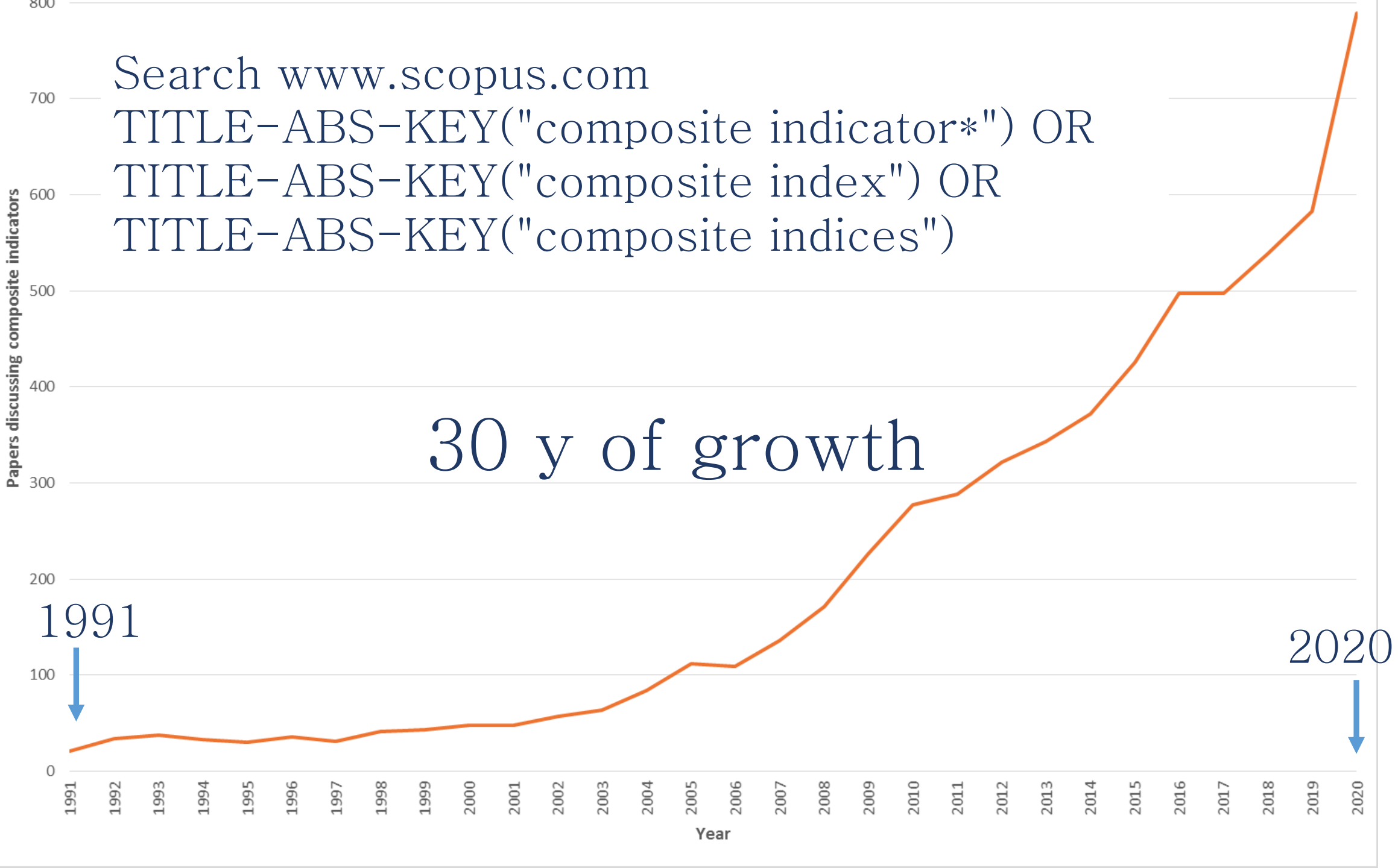
Eight factors further disaggregated into 44 sub-factors

1.1 Government powers are effectively limited by the legislature
1.2 Government powers are effectively limited by the judiciary
1.3 Government powers are effectively limited by independent auditing and review
1.4 Government officials are sanctioned for misconduct
1.5 Government powers are subject to non-governmental checks
1.6 Transition of power is subject to the law

One of the eight factors with its 6 sub factors …

https://worldjusticeproject.org/sites/default/files/documents/WJP-ROLI-2019-Single%20Page%20View-Reduced_0.pdf

Ubiquity of composite indicators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30 y of growth
1991
2020
Papers discussing composite indicators
Year
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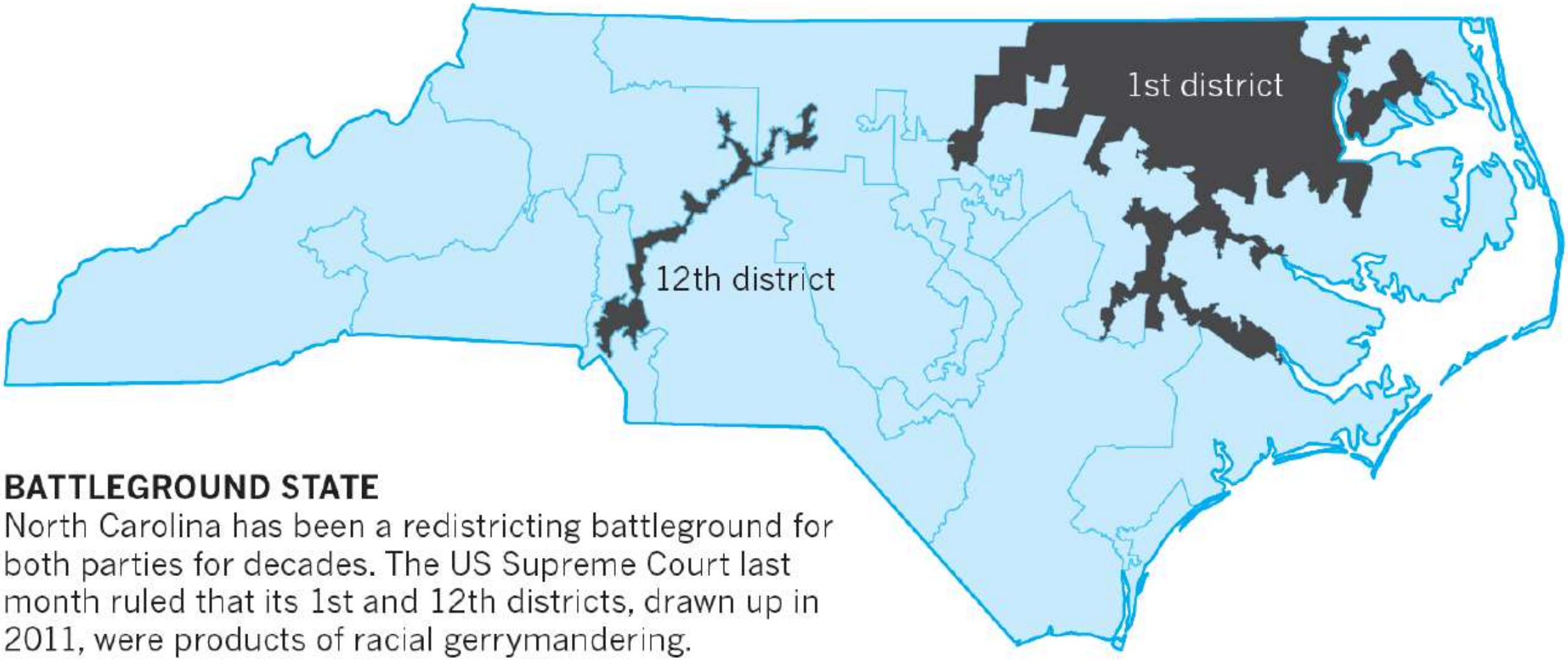
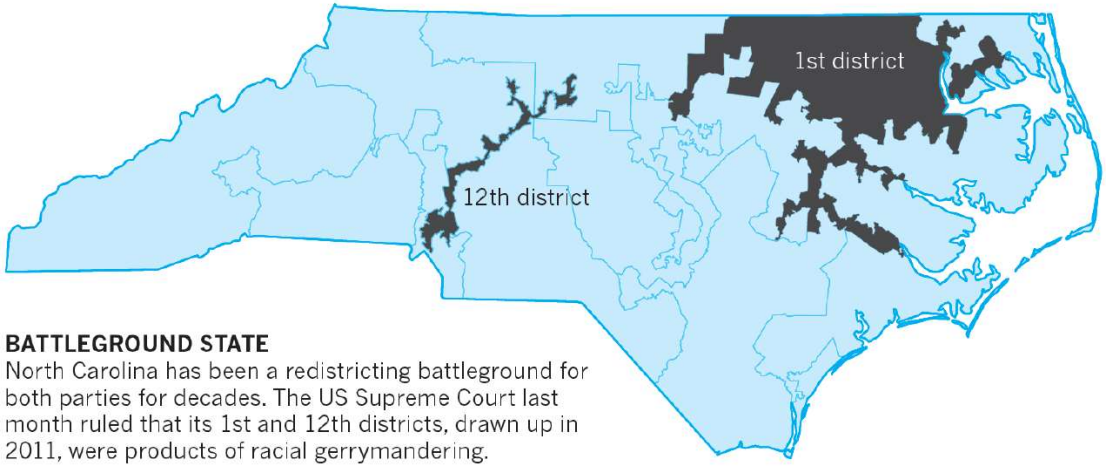
At times useful

Making the case for gerrymandering?



BATTLEGROUND STATE
North Carolina has been a redistricting battleground for both parties for decades. The US Supreme Court last month ruled that its 1st and 12th districts, drawn up in 2011, were products of racial gerrymandering.

Nature article on the mathematics of ‘nailing’ gerrymandering



BATTLEGROUND STATE
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“[US] ranked 55th of 158 nations — last among Western democracies — in a 2017 index of voting fairness (Electoral Integrity Project)”

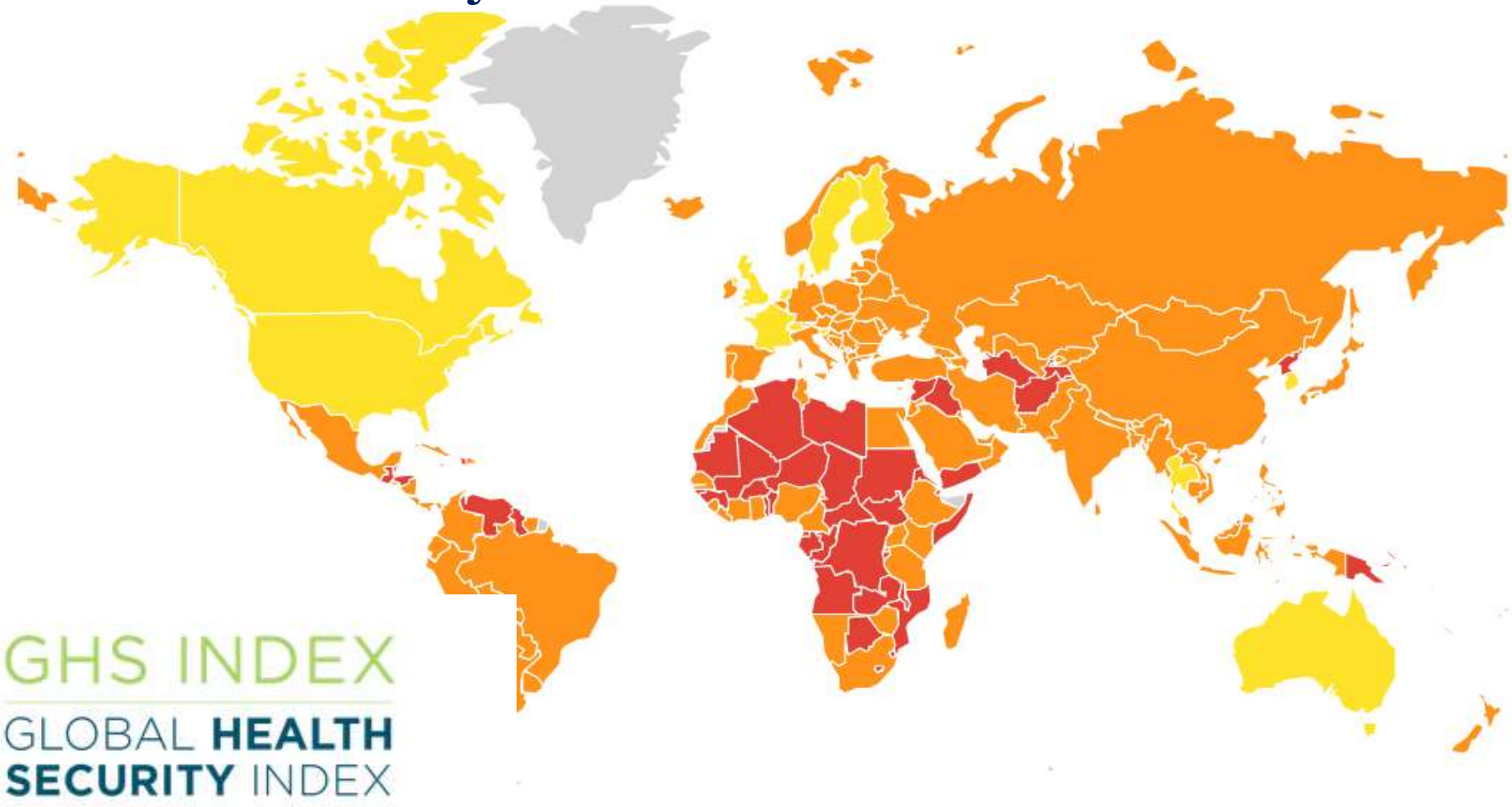
Carrie Arnold, 2017, The mathematicians who want to save democracy, 200, NATURE, VOL 546, 8 JUNE 2017.

At times problematic

The Global Health Security Index, released 2019 to "spur measurable changes in national health security" in light of "high-consequence and globally catastrophic biological events"

Cameron, E.E. et al., Global Health Security Index. Building Collective Action and Accountability. Nuclear Threat Initiative & Johns Hopkins Center for Health Security (October 2019). Available at https://www.ghsindex.org/#l-section--map.

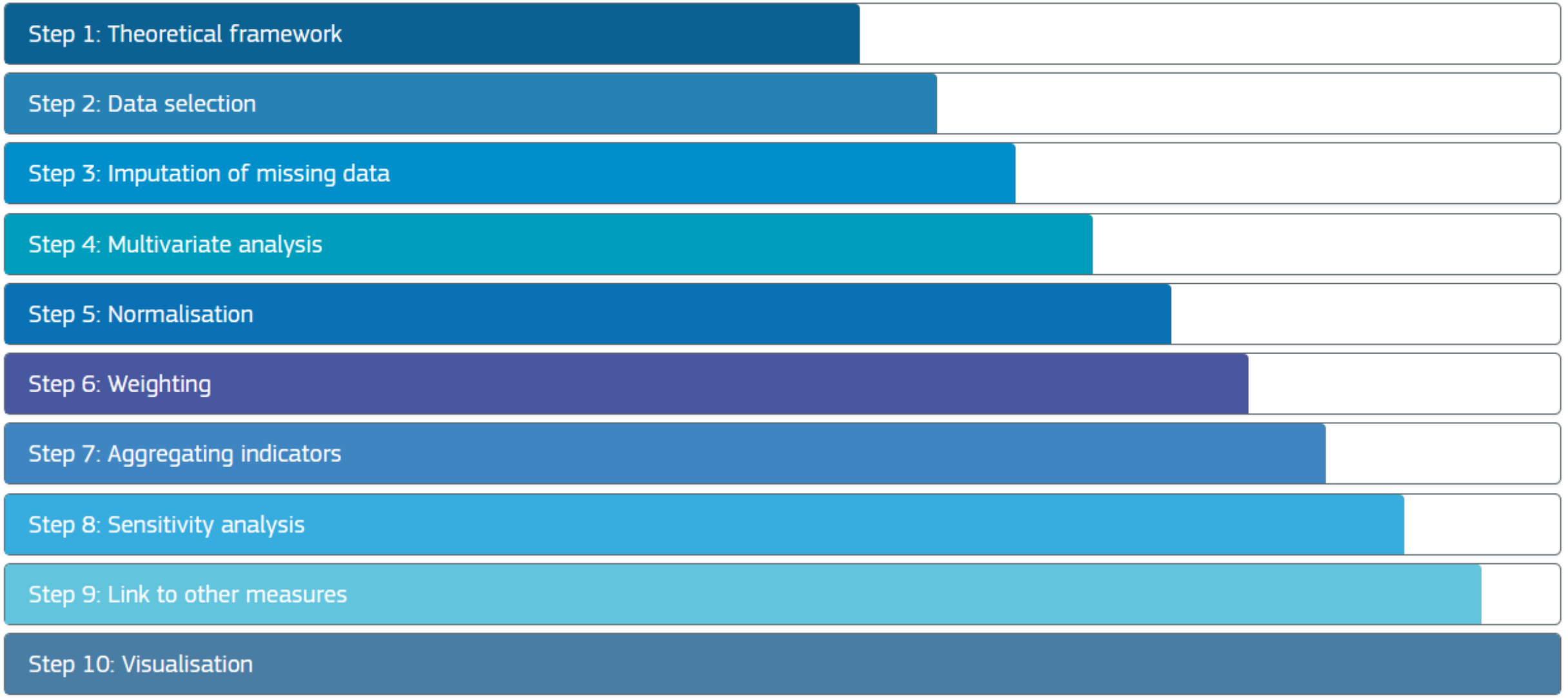
US and UK rank 1 and 2 respectively in Global Health Security



M. Kaiser, A. T.-Y. Chen, and P. Gluckman, "Should policy makers trust composite indices? A commentary on the pitfalls of inappropriate indices for policy formation," arXiv.org, vol. 2008.13637, Aug. 2020.

Ten steps, pros and cons, quality, …

OECD JRC



Source: https://composite-indicators.jrc.ec.europa.eu/?q=10-step-guide

Quality of composite indicators

RELEVANCE

In the context of composite indicators, relevance has to be evaluated considering the degree to which it meet current and potential needs of the users

[…] ensure that the right range of domains is covered in a balanced way

ACCURACY

The credibility of data products refers to confidence that users place in … the image of the data producer, i.e., the brand image …

[crucial] that the data are perceived to be produced professionally and that practices are transparent

(for example, data are not manipulated, nor their release timed in response to political pressure)

COHERENCE

… ensure coherence over time and across countries …
Coherence across countries implies that from country to country the data are based on common concepts, definitions, classifications and methodology, or that any differences can be justified

Critique of composite indicators: the Fitoussi-Stiglitz-Sen report

"The role [of statistical indicators] has increased significantly over the last two decades.

This reflects improvements in the level of **education** in the population, increases in the **complexity** of modern economies and the widespread use of **information technology**"

Jean-Paul Fitoussi,
Amartya Sen, Joseph Stiglitz

CMEPSP (2009). Commission on the Measurement of Economic Performance and Social Progress, URL: http://ec.europa.eu/eurostat/documents/118025/118123/Fitoussi+ Commission+ report, last accessed June 2017.

“a general criticism … frequently addressed at composite indicators, i.e. the arbitrary character of the procedures used to weight their various components […]

Jean-Paul Fitoussi,
Amartya Sen, Joseph Stiglitz

[…] an aggregation procedure always means putting relative values on the items that are introduced in the index”

CMEPSP (2009). Commission on the Measurement of Economic Performance and Social Progress, URL: http://ec.europa.eu/eurostat/documents/118025/118123/Fitoussi+ Commission+ report, last accessed June 2017.

"The problem is not that these weighting procedures are hidden, non-transparent or non-replicable – they are often very explicitly presented by the authors of the indices, and this is one of the strengths of this literature.

Jean-Paul Fitoussi,
Amartya Sen, Joseph Stiglitz

The problem is rather that their normative implications are seldom made explicit or justified"

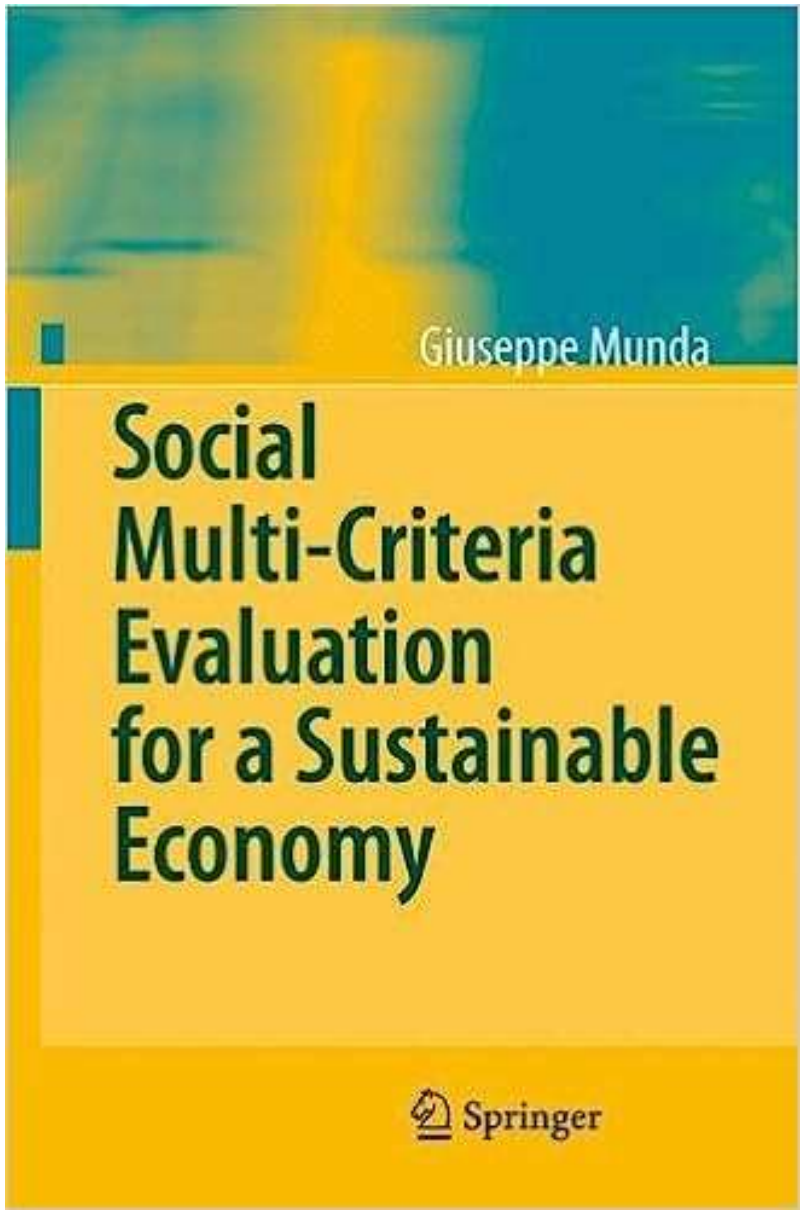
CMEPSP (2009). Commission on the Measurement of Economic Performance and Social Progress, URL: http://ec.europa.eu/eurostat/documents/118025/118123/Fitoussi+ Commission+ report, last accessed June 2017.

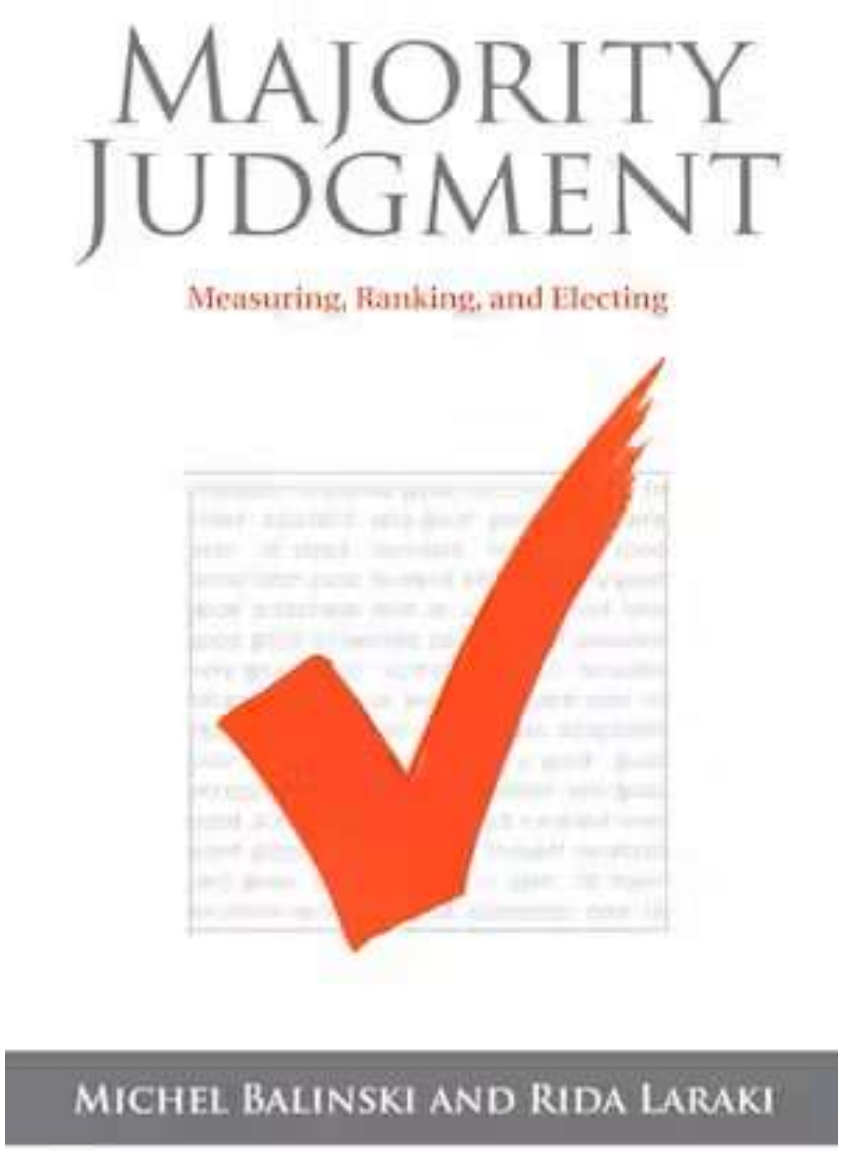
Before embarking in building a CI, consider their theory;

Linear aggregation or multi criteria?

Condorcet of Borda?

Do I accept compensability?





Testing composite indicators

Tools for evidence appraisal such sensitivity analysis and sensitivity auditing can be useful to gauge (and possibly deconstruct or reinforce) these measures

Sensitivity analysis

PDF

Info

Series A
Statistics in Society

Explore this journal >

Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators

M. Saisana, A. Saltelli, S. Tarantola

First published: 3 March 2005 Full publication history

DOI: 10.1111/j.1467-985X.2005.00350.x View/save citation

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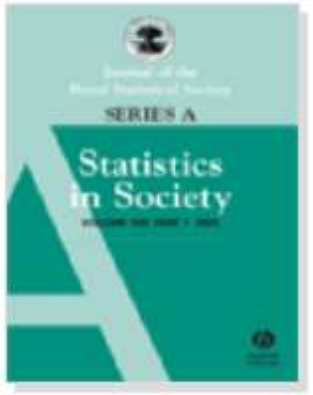
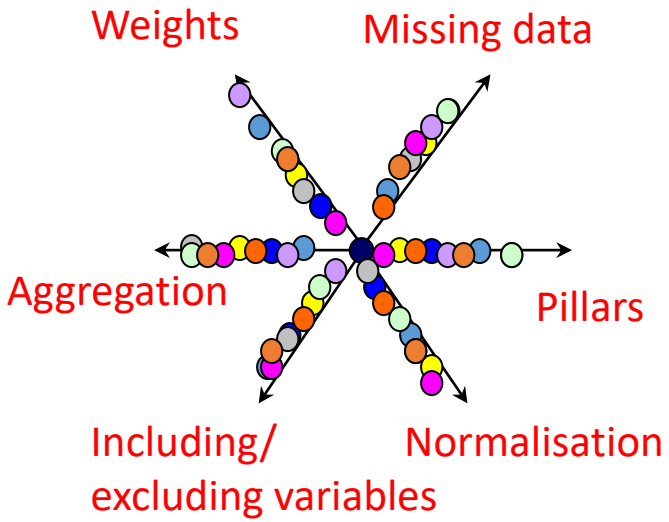
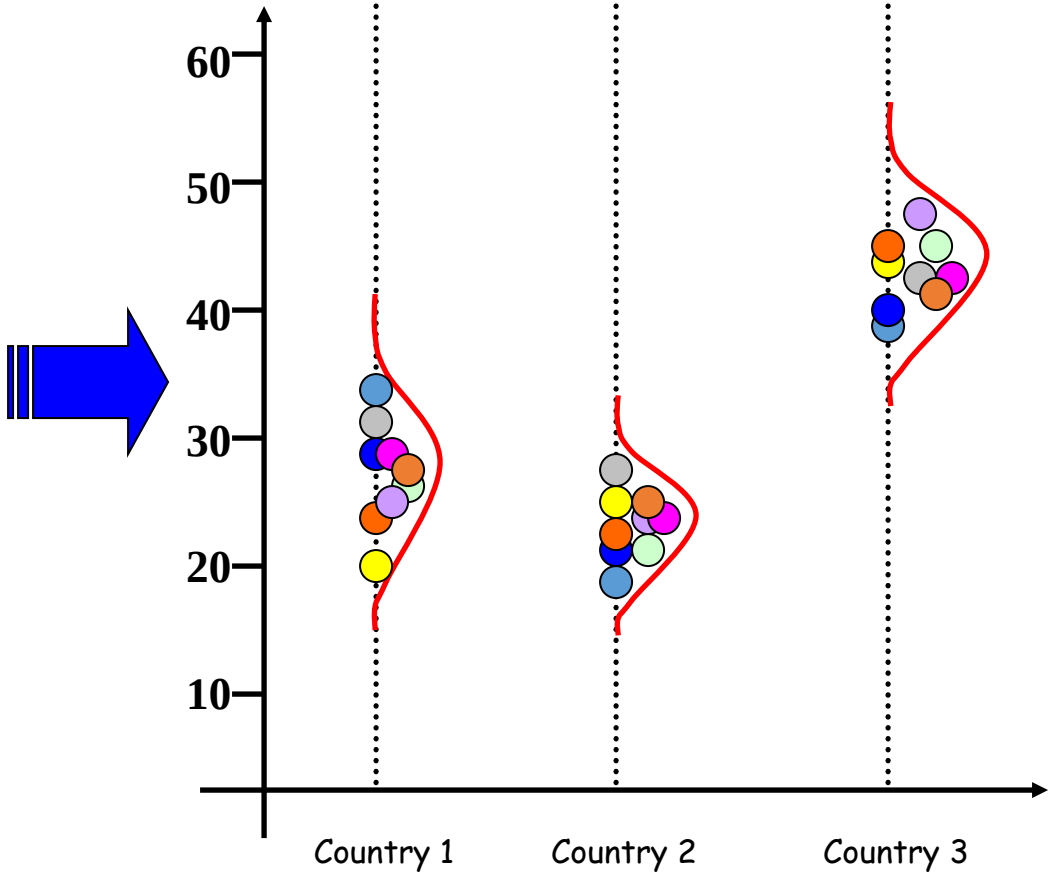


View issue TOC
Volume 168, Issue 2
March 2005
Pages 307–323

Assumption	**Alternatives**
Number of indicators	▪ all six indicators included or one-at-time excluded (6 options)
Weighting method	▪ original set of weights, ▪ factor analysis, ▪ equal weighting, ▪ data envelopment analysis
Aggregation rule	▪ additive, ▪ multiplicative, ▪ Borda multi-criterion

Space of alternatives





Sensitivity analysis to compare volatility of ranking

Research Policy 40 (2011) 165–177

Contents lists available at ScienceDirect

Research Policy

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

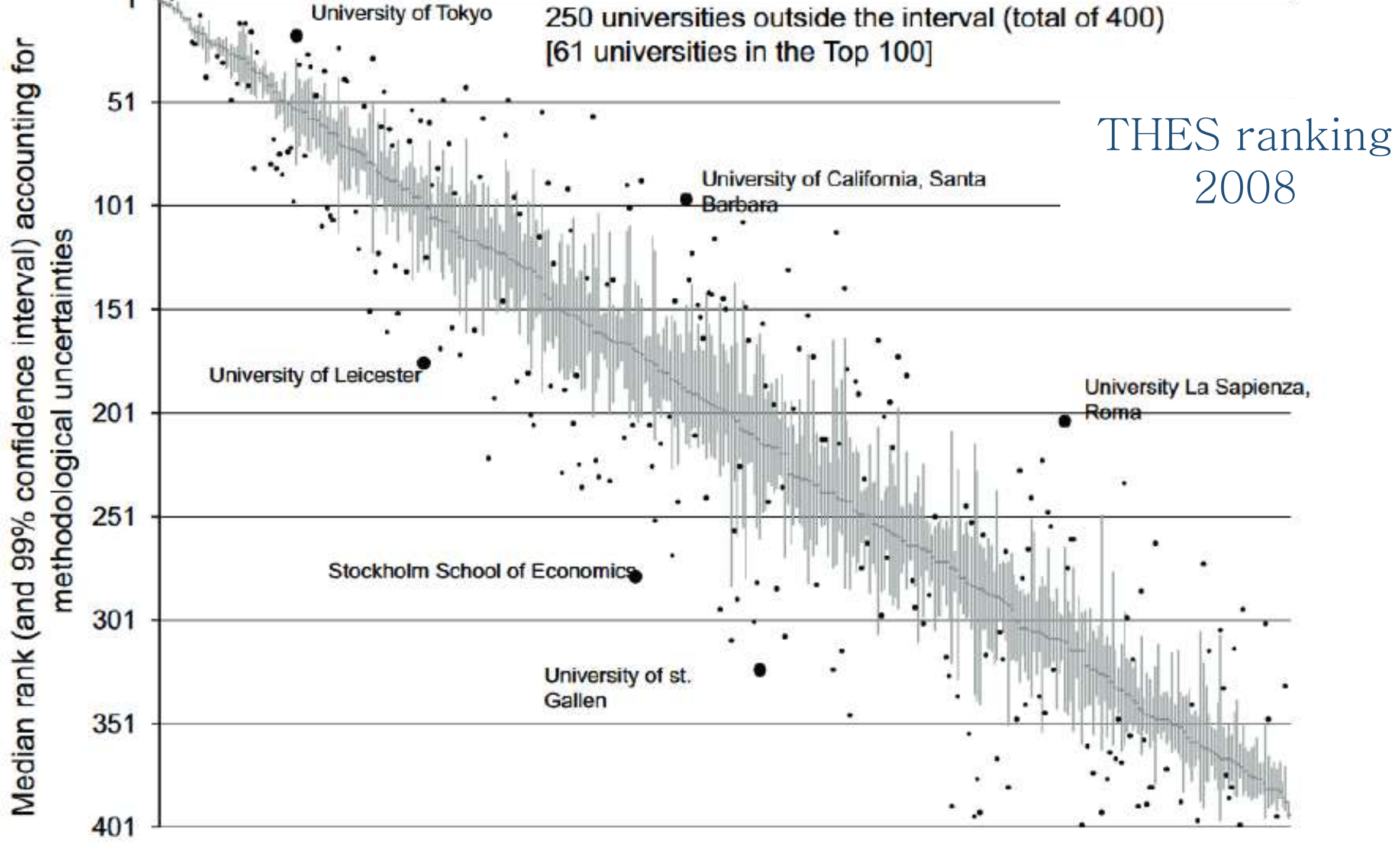
Rickety numbers: Volatility of university rankings and policy implications

Michaela Saisana*, Béatrice d'Hombres, Andrea Saltelli

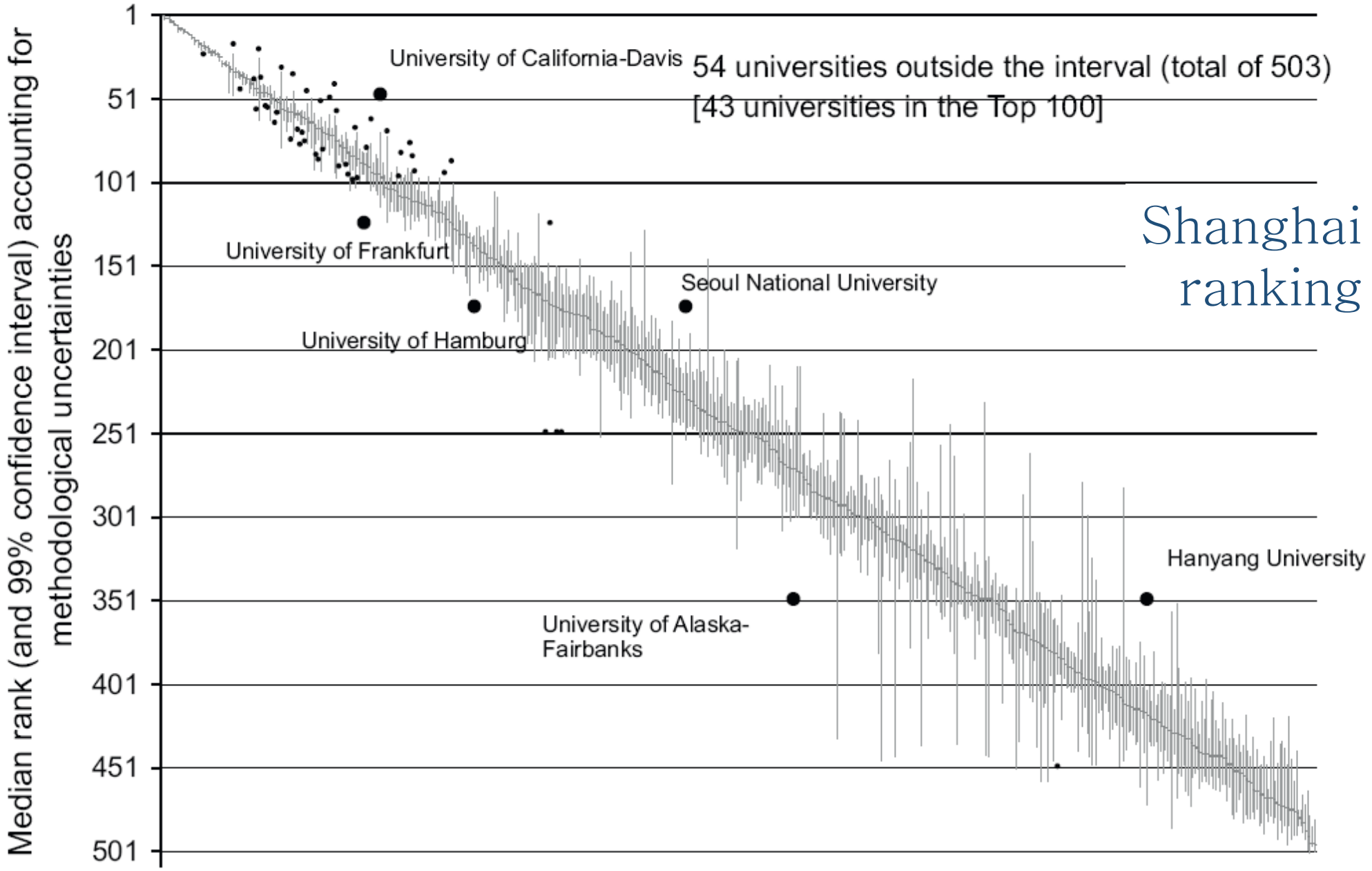
Econometrics and Applied Statistics, Joint Research Centre, European Commission, Enrico Fermi 2749, 21027 Ispra, Italy

Sensitivity analysis to compare volatility of ranking

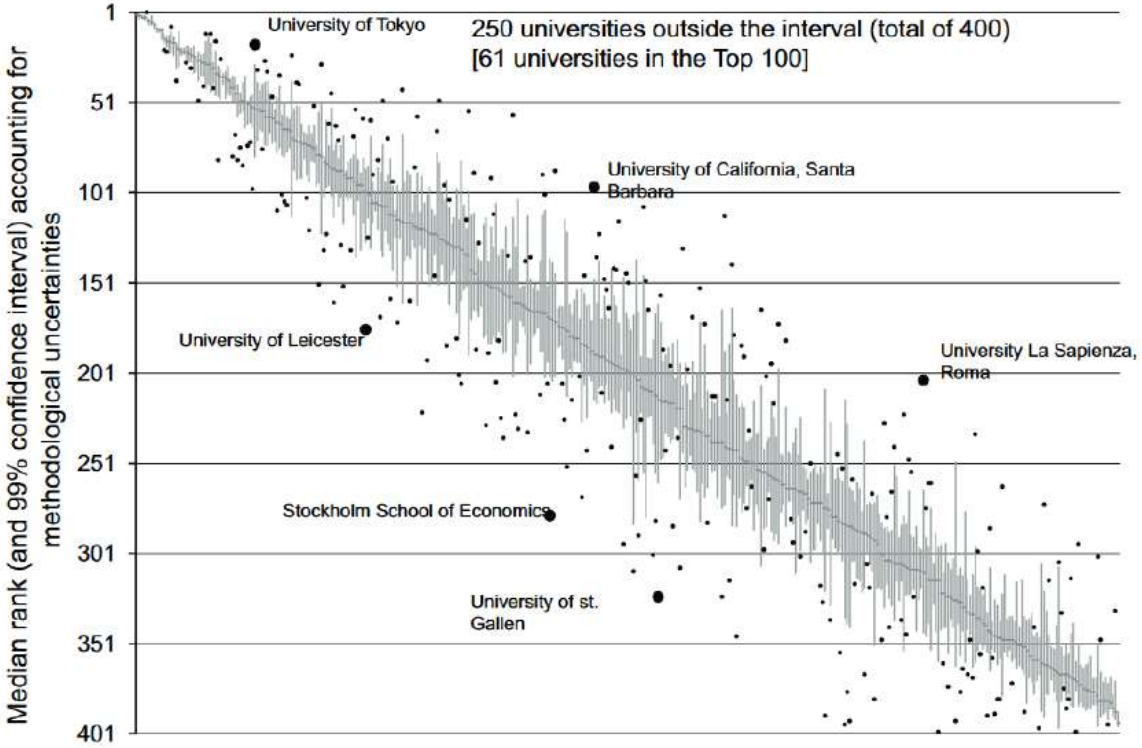
An ‘invasive’ analysis as the developers’ choices are questioned/varied



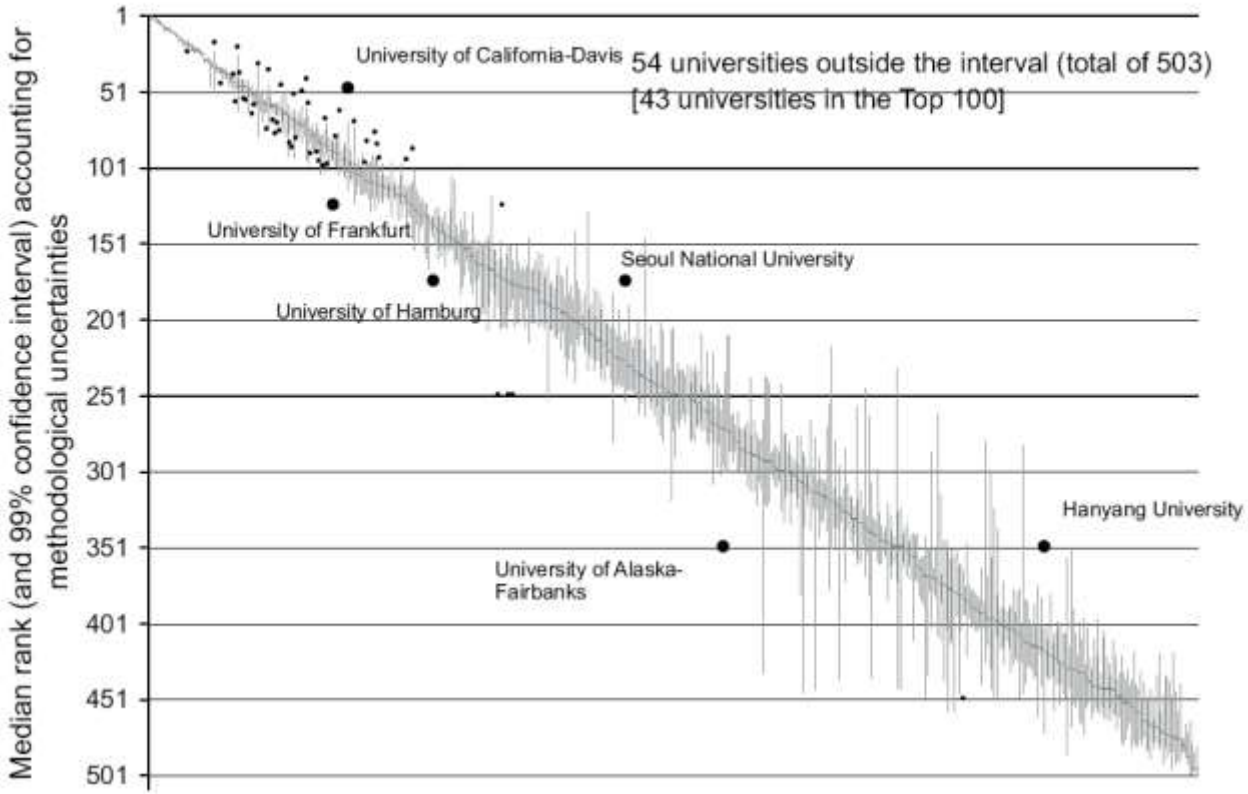
THES ranking 2008



Shanghai ARWU ranking 2008



THES ranking 2008



Shanghai ARWU ranking 2008

One can test whether assigned weights correspond to real importance

Journal of the Royal Statistical Society
SERIES A Statistics in Society

J. R. Statist. Soc. A (2013)
176, *Part* 3, *pp.* 609–634

Ratings and rankings: voodoo or science?

Paolo Paruolo

University of Insubria, Varese, Italy

and Michaela Saisana and Andrea Saltelli

European Commission, Ispra, Italy

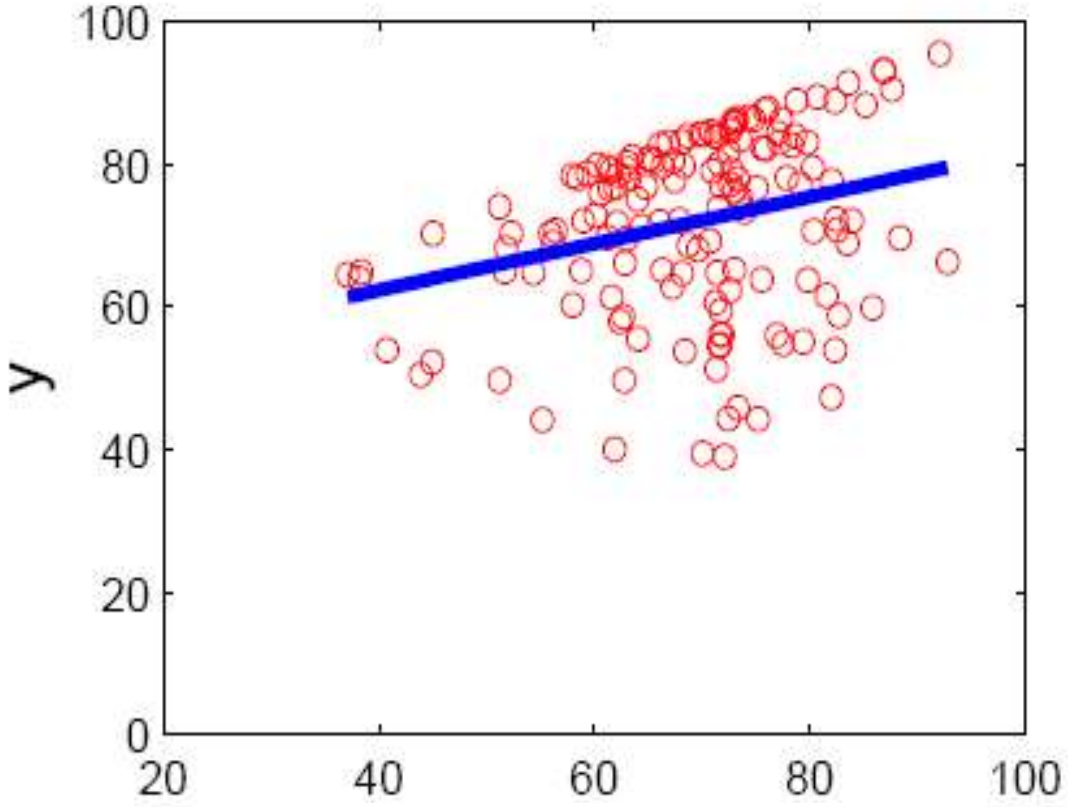
The linear aggregation paradox: **weights are used as if they were importance coefficients** while they are trade-off coefficients

An example. A dean wants to rank teachers based on ‘hours of teaching’ and ‘number of publications …

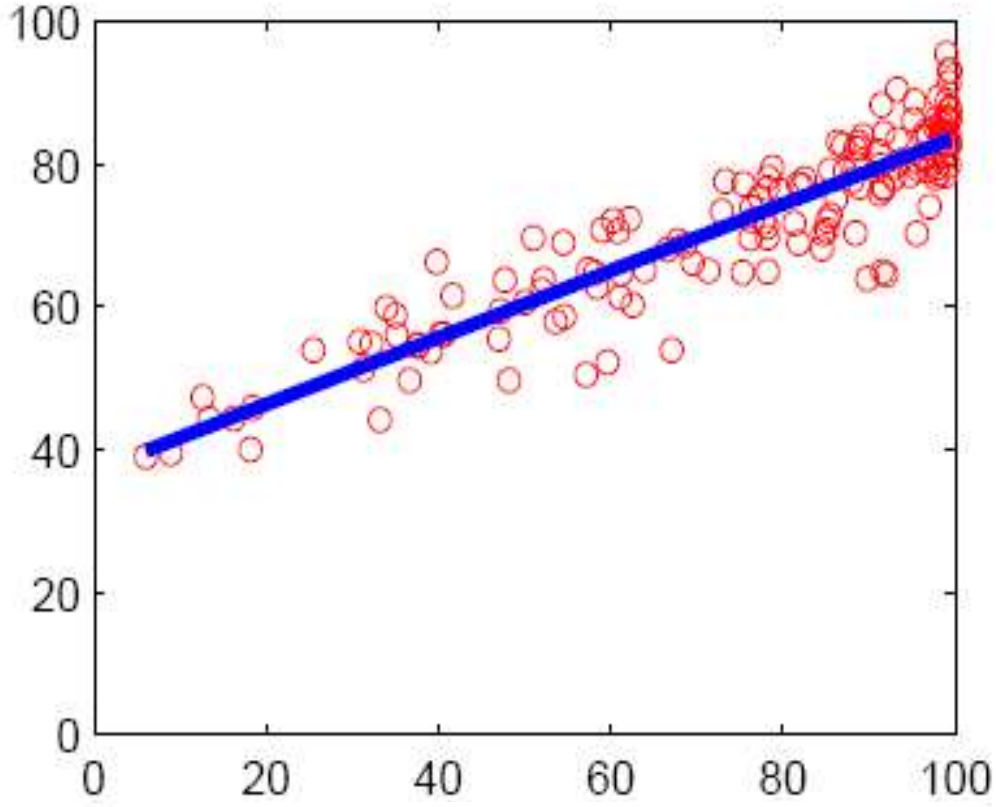
$$Y=0.5X_1 + 0.5X_2$$

X_1: hours of teaching
X_2: number of publications

… adding these two variables up she sees that teachers are practically ranked by publications alone



hours of teaching



number of publications

Dean's example: $y=x_1+x_2$.

Estimated $R_{ht}^2 = 0.0759$, $R_{np}^2 = 0.826$

To obviate this the dean substitutes the model

$$y=0.5x_1+0.5x_2$$

with

$$y=0.7x_1+0.3x_2$$

A professor comes by, looks at the last formula, and complains that publishing is disregarded in the department …

Comparing assigned weights versus measured importance for the 2009 and 2010 versions of the Human Development index

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KTH VETENSKAP OCH KONST
PAUL SCHERRER INSTITUT PSI
(FRS) FUTURE RESILIENT SYSTEMS 未来 韧性 系统
ETH zürich
European Commission

Composite Indicator Analysis and Optimization (CIAO) Tool

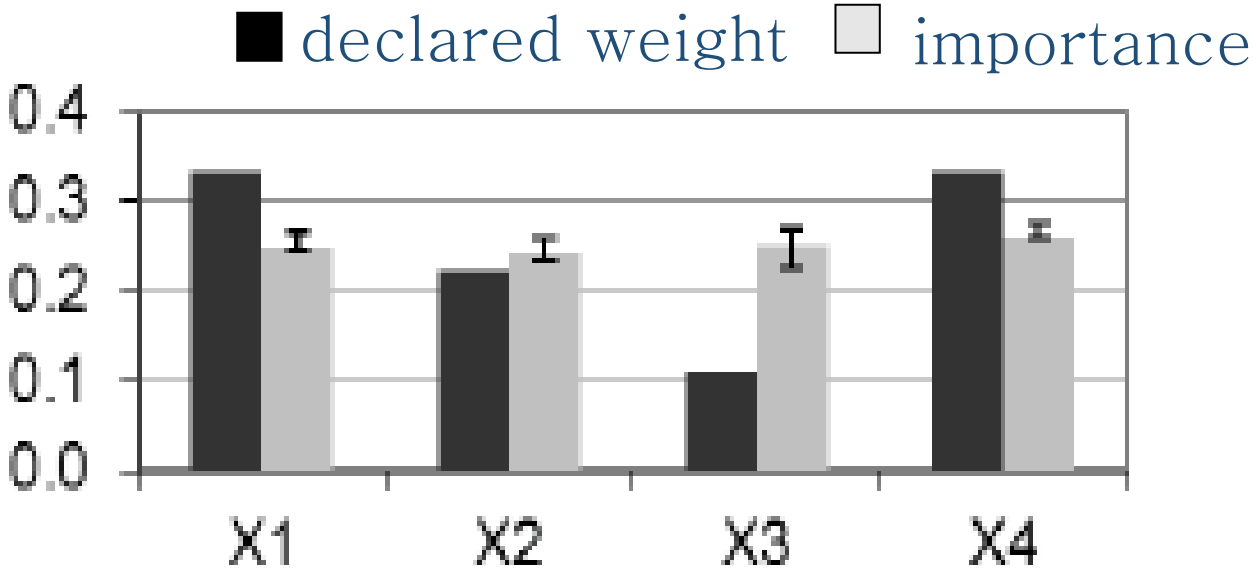
Codebook for practitioners, v.2

v.2: Revision January 2021

(v.1: November 2018)

David Lindén[1,2]
Dr. Marco Cinelli[2,3,*]
Dr. Matteo Spada[4,2]
Dr. William Becker[5]
Dr. Peter Burgherr[4,2]

HDI 2009



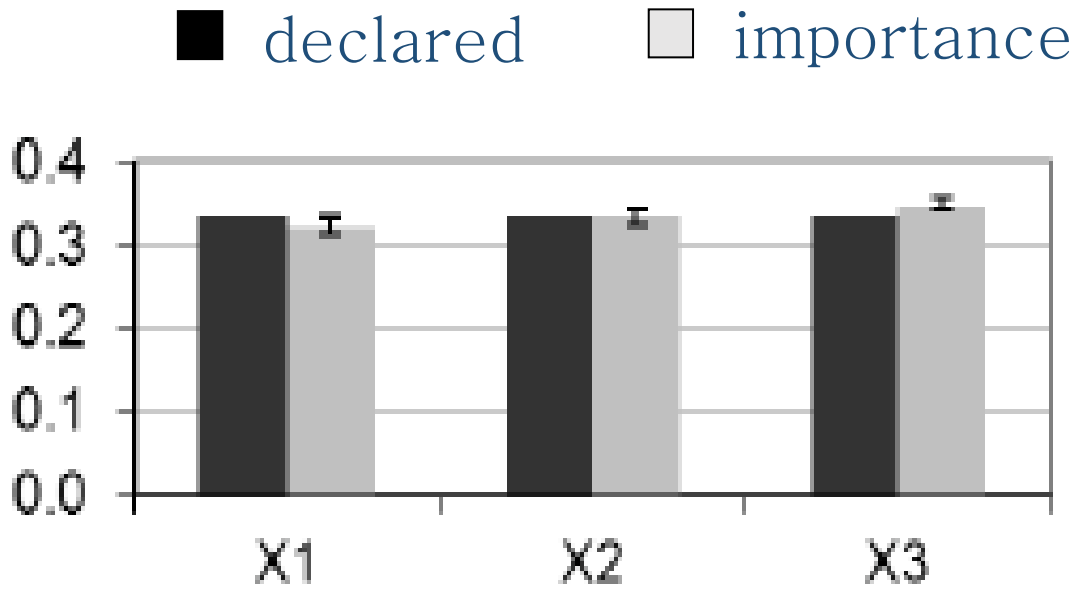
Life expectancy, 33%

Adult literacy, 22%

Enrollment education, 11%

GDP per capita, 33%

HDI
2010

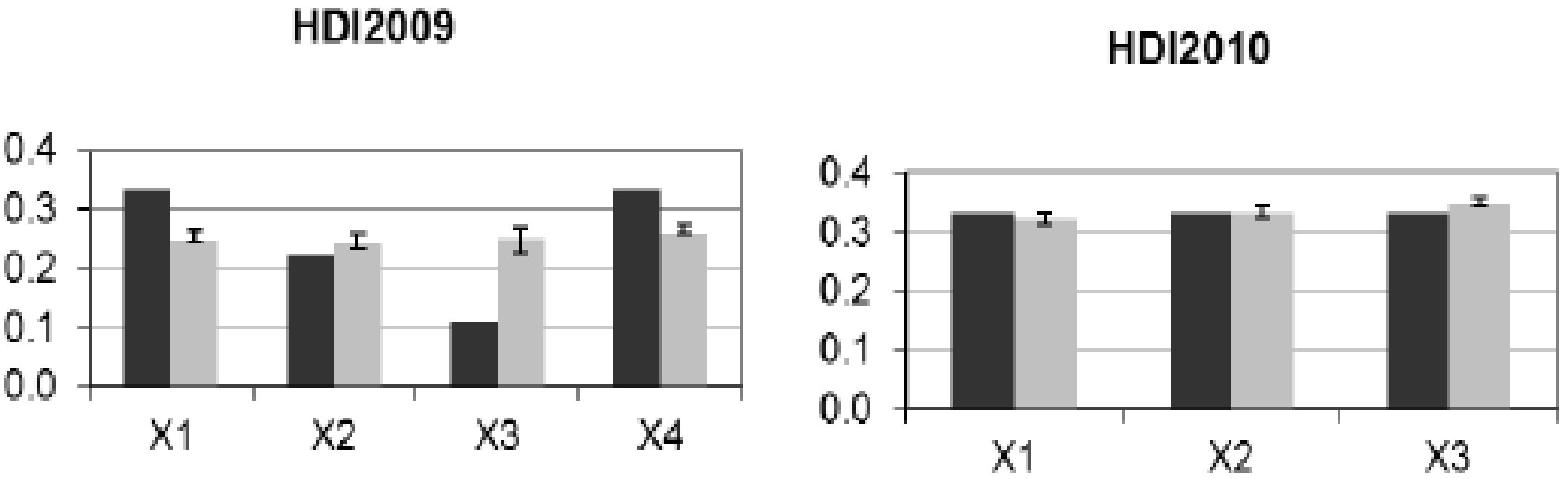


Life expectancy, 33%

Education, 33%

GNI per capita, 33%

declared weight importance



HDI 2010 more coherent than HDI 2009

(aggregation formula changed in 2010 from linear to geometric)

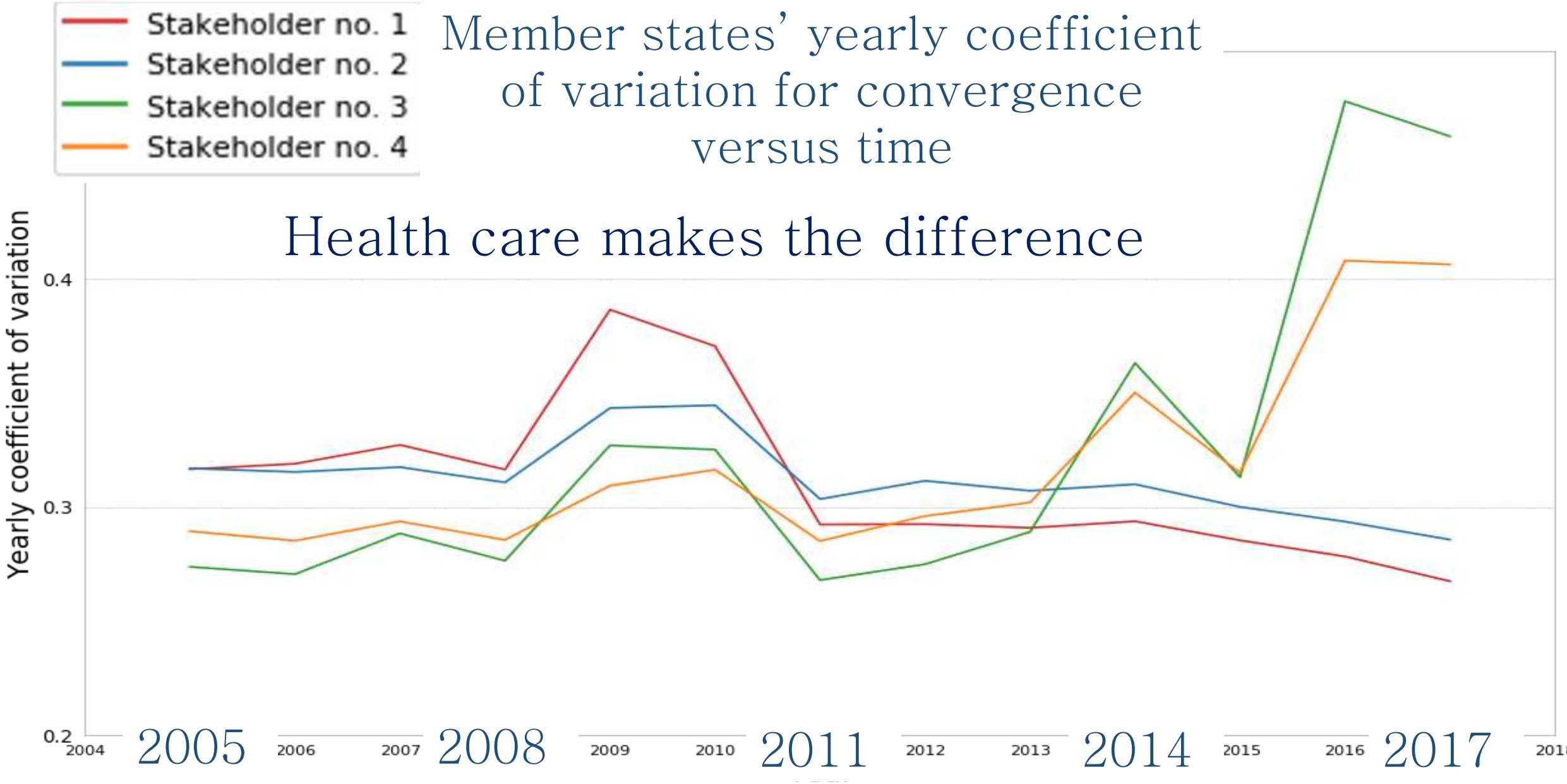
What if different stakeholders have different preferences? A test case of EU convergence analysis;

Four different viewpoints are compared

Stakeholder 1	Stakeholder 2	Stakeholder 3	Stakeholder 4
Access to labour market	Access to labour market	Access to labour market	Access to labour market
Fair working conditions	Fair working conditions	Fair working conditions	Fair working conditions
Social protection	Social protection	Social protection	Social protection
	Fairness	Health care	Fairness
			Health care

Member states' yearly coefficient of variation for convergence versus time

Health care makes the difference



Conclusions: CI – instructions for use

Be aware of the imperfections and non-neutrality of measures

Be explicit about normative choices for assumptions, variables and weights

Investigate properties (uncertainty and sensitivity analysis)

Reading material

Balinski, Michel, and Rida Laraki. 2011. Majority Judgment: Measuring, Ranking, and Electing. Cambridge, Mass.
Kaiser, Matthias, Andrew Tzer-Yeu Chen, and Peter Gluckman. 2021. “Should Policy Makers Trust Composite Indices? A Commentary on the Pitfalls of Inappropriate Indices for Policy Formation.” Health Research Policy and Systems 19 (1): 40. https://doi.org/10.1186/s12961-021-00702-4.

Kuc-Czarnecka, Marta, Samuele Lo Piano, and Andrea Saltelli. 2020. “Quantitative Storytelling in the Making of a Composite Indicator.” Social Indicators Research 149(3), 77 (3): 775–802.

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Paruolo, Paolo, Michaela Saisana, and Andrea Saltelli. 2013. “Ratings and Rankings: Voodoo or Science?” Journal of the Royal Statistical Society: Series A (Statistics in Society) 176 (3): 609–34. https://doi.org/10.1111/j.1467-985X.2012.01059.x.

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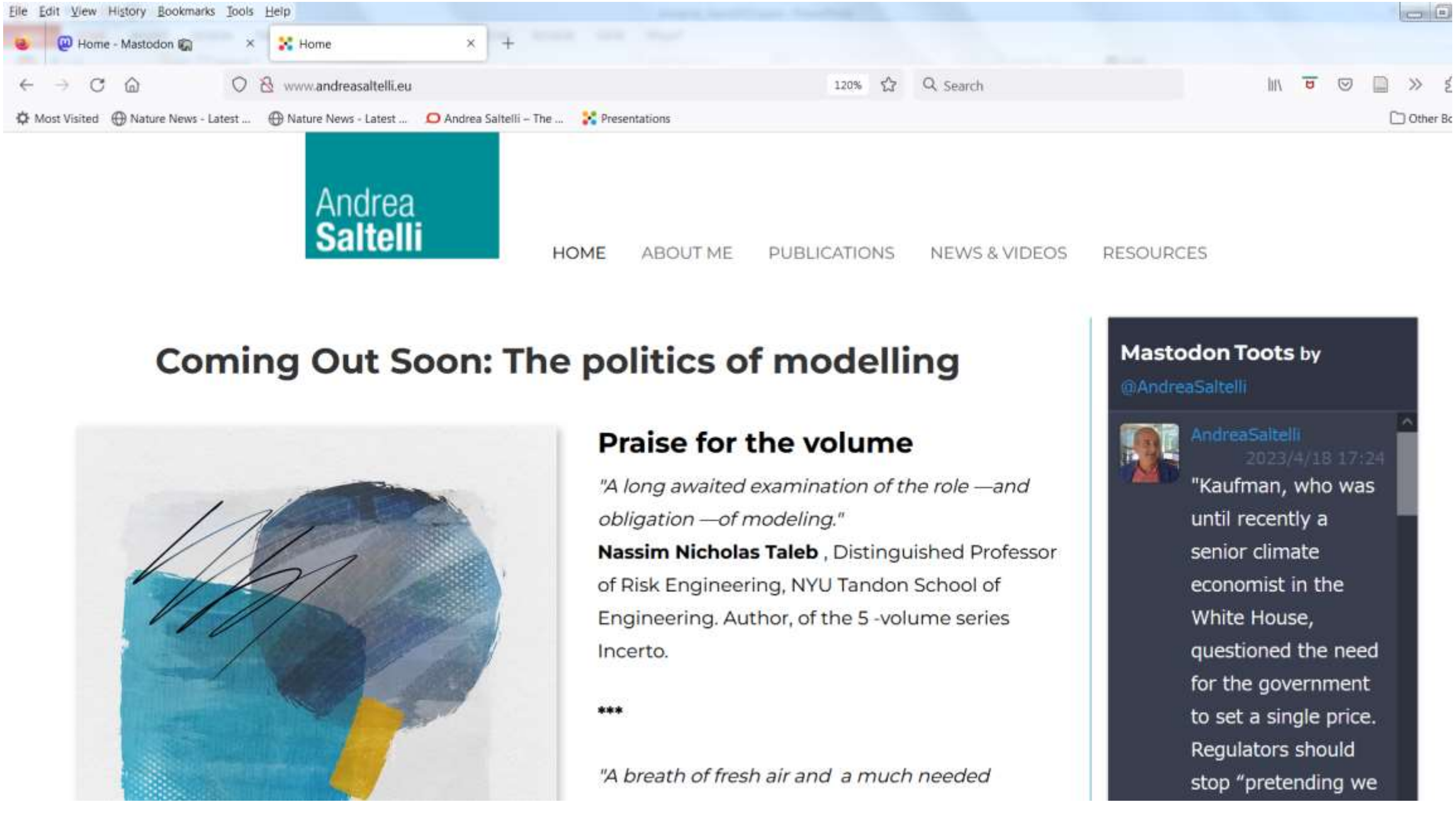
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