

Ethics of quantification

Course: Philosophy and ethics of social sciences Bergen and Vatnahalsen 13 – 17 February, 2017

Lesson: Ethics of Quantification

Andrea Saltelli Centre for the Study of the Sciences and the Humanities (SVT) - University of Bergen (UIB) Institut de Ciència i Tecnologia Ambientals (ICTA) -Universitat Autonoma de Barcelona (UAB)

Barcelona, Bellaterra Campus, February 6-8 2017



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





= more material on my web site



= discussion time

Context: A matter of opinion

- 1. Science is in a deep existential crisis which has ethical, epistemological, methodological and even metaphysical dimensions
- 2.Likewise democracy which has with science a legitimacy arrangement
- 3. Science and its institutions are committed to the status quo & attempt to evade a critical reflection
- 4. Solutions aren't forthcoming anytime soon
- 5. There are yet few areas of 'Reformation' where science and society work together

First thesis: Science is in a deep existential crisis which has ethical, epistemological, methodological and even metaphysical dimensions. This was neatly predicted by E. de Solla Price, Jerome R. Ravetz and others five decades ago







Jerome R. Ravetz

de Solla Price, D.J., 1963, Little science big science, Columbia University Press. Ravetz, J., 1971, Scientific Knowledge and its Social Problems, Oxford University Press.



Summary Points

• Currently, many published research findings are false or exaggerated, and an estimated 85% of research resources are wasted.

Ioannidis, J. P. (2014). How to Make More Published Research True. PLoS medicine, 11(10), e1001747

For Lancet (2015) an estimated US\$200 billion were wasted in the US in 2010.

Lancet, Editorial, 2015, Rewarding true inquiry and diligence in research, 385, p. 2121. Ioannidis JPA, 2016, Why Most Clinical Research Is Not Useful, PLoS Med 13(6): e1002049. doi:10.1371/journal.pmed.1002049



John P. A. Ioannides



NATURE | NEWS FEATURE

1,500 scientists lift the lid on reproducibi

Survey sheds light on the 'crisis' rocking research.

Monya Baker

25 May 2016 | Corrected: 28 July 2016



http://www.nature.com/news/1-500-scientistslift-the-lid-on-reproducibility-1.19970

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NATURE | NEWS FEATURE

1,500 scientists lift the lid on reproducibility

Survey sheds light on the 'crisis' rocking research.

Monya Baker

25 May 2016 | Corrected: 28 July 2016

WHAT FACTORS CONTRIBUTE TO IRREPRODUCIBLE RESEARCH?

Many top-rated factors relate to intense competition and time pressure.



http://www.nature.com/news/1-500-scientists- ona lift-the-lid-on-reproducibility-1.19970



THE RIGHTFUL PLACE OF SCIENCE: SCIENCE ON THE VERGE

CONTRIBUTORS

Alice Benessia	
Silvio Funtowicz	
Mario Giampietro	
Angela Guimarães Pereira	3

Jerome R. Ravetz Andrea Saltelli Roger Strand Jeroen P. van der Sluijs



A crisis looms over the scientific enterprise. Not a day passes without news of retractions, failed replications, fraudulent peer reviews, or misinformed science-based policies

The Rightful Place of Science: Science on the Verge

Paperback – 20 Feb 2016 by Andrea Saitelli (Author), Alice Benessia (Author), & 7 more



- See all formats and editions
- Kindle EditionPaperback£3.61£6.99

Thesis 2: Likewise in crisis is democracy which has with science a legitimacy arrangement



→ today post-BREXIT, post-Trump, post-truth brouhaha, the demise of expertise …

Thesis 3: Science and its institutions are committed to the status quo & attempt to evade a critical reflection with:

Denial Dismissal

Diversion Displacement

Economy and Society Volume 41 Number 1 February 2012: 107–125 Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses

Steve Rayner

Denial

OECDpublishing

Please cite this paper as:

OECD (2015), "Scientific Advice for Policy Making: The Role and Responsibility of Expert Bodies and Individual Scientists", OECD Science, Technology and Industry Policy Papers, No. 21, OECD Publishing, Paris. http://dx.doi.org/10.1787/5js3311jcpwb-en



OECD Science, Technology and Industry Policy Papers No. 21

Scientific Advice for Policy Making

THE ROLE AND RESPONSIBILITY OF EXPERT BODIES AND INDIVIDUAL SCIENTISTS

OECD

2015



We can solve it!

nature.com > nature human be	ehaviour > perspectives > article
human beha	viour
Altmetric: 1	,978 Views: 40,227 More detail »
Perspective OPEN	
A manifesto for	reproducible science
Marcus R. Munafò 🥌, Brian A. Nosek, Chambers, Nathalie Percie du Sert, U P. A. Ioannidis	Dorothy V. M. Bishop, Katherine S. Button, Christopher D. Jri Simonsohn, Eric-Jan Wagenmakers, Jennifer J. Ware & John
Nature Human Behaviour 1, Article number: 0021 (2017)	Published online: 10 January 2017

"[…] measures [to] improving the transparency, reproducibility and efficiency of scientific research"

Diversion (There is a problem, and this is due to an ongoing war on science between the educated liberal left and the ignorant conservative right)

THE CONVERSATION

Arts + Culture Business + Economy Education Environment + Energy Health + Medicine Politics + Society Science + Technology Brexit



Authors



B. Shard and the descent of

Andrea Saltelli Adjunct professor, University of Bergen



Silvio Oscar Funtowicz

Adjunct Professor Centre for the Study of the Sciences and the Humanities, University of Bergen

https://theconversation.com/science-wars-in-the-age-of-donald-trump-67594

Displacement (This is the post-truth era)



Academic rigour, journalistic flair

Arts + Culture Business + Economy Education Environment + Energy Health + Medicine Politics + Society Science + Technology Brexit

To tackle the post-truth world, science must reform itself

January 27, 2017 7.33am GMT



Authors



Andrea Saltelli Adjunct professor, University of Bergen



Silvio Oscar Funtowicz Adjunct Professor Centre for the Study of the Sciences and the Humanities, University of Bergen

https://theconversation.com/to-tackle-the-post-truth-world-science-must-reform-itself-70455

Thesis 4: Solutions aren't forthcoming anytime soon, but:

Church / indulgencies =

Science / predatory publishers, citation cartels, trade in authorship, sugar-cholesterol scandal …



Martin Luther



Johann Tetzel

A combination of corruption, rage and new technology could mobilise major social change (Silvio Funtowicz)



Martin Luther



Johann Tetzel

Thesis 5: Areas of resistance and 'Reformation' where science and society work together – emergence of a new polity of science, including citizen scientists and scientist–citizens



Jeffrey Beall

Lois Gibbs

Timothy Gowers Marc Edwards

http://scholarlyoa.com/2015/01/02/bealls-list-of-predatory-publishers-2015/#more-4719 https://www.bu.edu/lovecanal/canal/ http://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0127502 https://en.wikipedia.org/wiki/Flint_water_crisis; http://flintwaterstudy.org/; http://www.nytimes.com/2016/08/21/magazine/flints-water-crisis-and-thetroublemaker-scientist.html

An even newer sort of heroes?



John and Laura Arnold









Brian Nosek, the Reproducibility Project.

John Ioannidis, Meta-research innovation centre at Stanford

Ben Goldacre, alltrials.net

Gary Taubes, The case against sugar

https://www.wired.com/2017/01/john-arnold-waging-war-on-bad-science/



Yoshiki Sasai

http://www.nature.com/news/stem-cell-pioneer-blamed-media-bashing-in-suicide-note-1.15715

Discussion points



• Free instant poll: is so bad?

Problematic quantifications?



Home / Pathways Leading to a More Sustainable and Healthy Global Food System

Topics Agriculture & Food | Food Security | Health

Pathways Leading to a More Sustainable and Healthy Global Food System

Volume 71 Issue 51 Page 10-121 September 2016 By Krishna Bahadur KC, Evan D.G. Fraser, Samantha Pascoal, Goretty Dias, Trudi Zundel



"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"

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

"[…] 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." 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 ~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"



How did we get here?

Why quantification becomes an instrument of hypocognition?

What is a socially constructed ignorance?

All starts with a dream:



Francis Bacon (1561-1626)

We call the Cartesian dream the idea of man as master and possessor of nature, of prediction and control, of Bacon's wonders of science and of Condorcet's mathematique sociale…



René Descartes (1596-1650)

Magnalia Naturae, in the New Atlantis (1627), '*Wonders of nature, in particular with respect to human use*'



Nicolas de Caritat, marquis de Condorcet (1743- 1794)

'Sketch for a Historical Picture of the Progress of the Human Spirit' Discourse on Method (1637)



Francis Bacon (1561–1626)

Magnalia Naturae, in the New Atlantis (1627), 'Wonders of nature, in particular with respect to human use'

The prolongation of life; The restitution of youth in some degree; The retardation of age; The curing of diseases counted incurable; The mitigation of pain; More easy and less loathsome purgings; The increasing of strength and activity; The increasing of ability to suffer torture or pain; The altering of complexions, and fatness and leanness; The altering of statures; The altering of features; The increasing and exalting of the intellectual parts; Versions of bodies into other bodies; Making of new species; Transplanting of one species into another; Instruments of destruction, as of war and poison; Exhilaration of the spirits, and putting them in good disposition; Force of the imagination, either upon another body, or upon the body itself; Acceleration of time in maturations; Acceleration of time in clarifications; Acceleration of putrefaction; Acceleration of decoction; Acceleration of germination; Making rich composts for the earth; Impressions of the air, and raising of tempests; Great alteration; as in induration, emollition, &c; Turning crude and watery substances into oily and unctuous substances; Drawing of new foods out of substances not now in use; Making new threads for apparel; and new stuffs, such as paper, glass, &c; Natural divinations; Deceptions of the senses; Greater pleasures of the senses; Artificial minerals and cements.



Francis Bacon (1561-1626)

Magnalia Naturae, in the New Atlantis (1627), 'Wonders of nature, in particular with respect to human use'

The prolongation of life; The restitution of youth in some degree; The retardation of age; The curing of diseases counted incurable; The mitigation of pain; [...]

Drawing of new foods out of substances not now in use; Making new threads for apparel; and new stuffs, such as paper, glass, &c; Natural divinations; Deceptions of the senses; Greater pleasures of the senses; Artificial minerals and cements. The study of letters leading to "doubts and errors";

Comparing "disquisitions of the ancient moralists to very towering and magnificent palaces with no better foundation than sand and mud";

Condemnation of humanities and exaltation of mathematics.



René Descartes (1596-1650)

Discourse on Method (1637) "I perceived it to be possible to arrive at knowledge highly useful in life; and in room of the Speculative Philosophy […], to discover a Practical, by means of which, knowing the force and action of fire, water, air, the stars, the heavens, and all the other bodies that surround us, […] we might also apply them $[\cdots]$, and thus render ourselves the lords and possessors of nature."



René Descartes (1596-1650)

Discourse on Method (1637)

In the formulation of Condorcet:

"All the errors in politics and in morals are founded upon philosophical mistakes, which, themselves, are connected with physical errors" (Ninth Epoch)



Nicolas de Caritat, marquis de Condorcet (1743- 1794)

'Sketch for a Historical Picture of the Progress of the Human Spirit'
Overpopulation? War due to scarcity of resources? Will not happen because technical progress and ethical progress will go hand in hand. Man will understand that his duty "will consist not in the question of giving existence to a greater number of beings, but happiness." (Tenth Epoch)



Nicolas de Caritat, marquis de Condorcet (1743- 1794)

'Sketch for a Historical Picture of the Progress of the Human Spirit' 'Mathématique sociale':

We still use today terms such as 'Condorcet method', 'Condorcet winner', 'Condorcet-ranking procedure'



Nicolas de Caritat, marquis de Condorcet (1743- 1794)

'Sketch for a Historical Picture of the Progress of the Human Spirit' Condorcet's algorithms and Descartes' Geometry

Feldman, J., 2005, Condorcet et la mathematique sociale: enthousiasmes et bemols, Mathematics and Social Sciences, 172(4), 7-41, http://www.ehess.fr/revue-msh/pdf/N172R955.pdf Munda G. (2007) - Social multi-criteria evaluation, Springer-Verlag, Heidelberg, New York, Economics Series



Condorcet's algorithms and Descartes' Geometry, the dream always had a quantification agenda







Making the dream true: Gravitational waves; from J. Weber's cylinder to LIGO

A Madman Dreams of Tuning Machines: The Story of Joseph Weber, the Tragic Hero of Science Who Followed Einstein's Vision and Pioneered the Sound of Space-Time, By Maria Popova, https://www.brainpickings.org/2016/04/25/black-holeblues-janna-levin-joseph-weber/



Closer to our times the dream was couched in the 'Endless Frontier' metaphor by Vannevar Bush, 1945:

"One of our hopes is that after the war there will be full employment. $[\cdots]$ To create more jobs we must make new and better and cheaper products […] founded on […] basic scientific research. […the] Government […] opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains."

Bush, V. (1945) Science: the endless frontier, United States Office of Scientific Research and Development, U.S. Govt. print office.



Vannevar Bush (1890-1974)

If you are a natural scientists you were nourished and trained in the Cartesian dream, what S. Toulmin called 'The hidden agenda of modernity'

The dream was spectacularly successful, in all fields of endeavor, leading to what Steven Shapin calls 'invisible science'

It also lead to techno-science, to technology 'creating itself from itself',...

Steven Shapin, 2016, Invisible Science, The Hedgehog Review: Vol. 18 No. 3 (Fall 2016)

W.B. Arthur, The nature of technology, Free Press, New York, 2009.



Steven Shapin





... To a technology which redefines the meaning of 'knowing' into 'Googleknowing'



... To a world impossible to make sense of

Essay

John P. A. Ioannidis

Why Most Published Research Findings Are False

J. P. A. Ioannidis, Why Most Published Research Findings Are False, PLoS Medicine, August 2005, 2(8), 696-701.



генатопопро ртоюса посаен зекстание field. In this framework, a research finding is less likely to be true when the studies conducted in a field are smaller; when effect sizes are smaller; when there is a greater number and lesser preselection of tested relationships; where there is greater flexibility in designs, definitions, outcomes, and analytical modes; when there is greater financial and other interest and prejudice; and when more teams are involved in a scientific field in chase of statistical significance.

A collapse in craft skills?



Statisticians issue warning on *P* values

Statement aims to halt missteps in the quest for certainty.

"Misuse of the P value — a common test for judging the strength of scientific evidence — is contributing to the number of research findings that cannot be reproduced"

Baker, M., 2016, Statisticians issue warning on P values, Nature, 531, 151



AMERICAN STATISTICAL ASSOCIATION Promoting the Practice and Profession of Statistics

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AMERICAN STATISTICAL ASSOCIATION RELEASES STATEMENT ON STATISTICAL SIGNIFICANCE AND P-VALUES

Provides Principles to Improve the Conduct and Interpretation of Quantitative Science March 7, 2016

... and twenty 'dissenting' commentaries

Wasserstein, R.L. and Lazar, N.A., 2016. 'The ASA's statement on p-values: context, process, and purpose', The American Statistician, DOI:10.1080/00031305.2016.1154108.

See also Christie Aschwanden at http://fivethirtyeight.com/features/not-even-scientists-can-easily-explain-p-values/

Unlikely results

How a small proportion of false positives can prove very misleading



true

http://www.economist.com/blogs/g raphicdetail/2013/10/daily-chart-2

ROYAL SOCIETY OPEN SCIENCE

rsos.royalsocietypublishing.org



Cite this article: Colquhoun D. 2014 An investigation of the false discovery rate and the misinterpretation of *p*-values. *R. Soc. open sci.* **1**: 140216.

http://dx.doi.org/10.1098/rsos.140216

An investigation of the false discovery rate and the misinterpretation of *p*-values

David Colquhoun

Department of Neuroscience, Physiology and Pharmacology, University College London, Gower Street, London WC1 6BT, UK How was it possible that this important statistical tool was misused for several decades with grave consequences for science?

Same story as with sensitivity analysis, with the aggravating circumstance that statistics is a well established discipline while SA is not

What if even she is wrong?



On TV series over series where lab-based forensics (science) adjudicates cases

Forensics [as well as medicine, biology, economics, health, nutrition ...] has produced serious misdiagnoses





National Academy of Sciences (NAS) report "Strengthening Forensic Science in the United States: A Path Forward", https://www.ncjrs.gov/pdffiles1/nij/grants/228091.pdf



Science in crisis: from the sugar scam to Brexit, our faith in experts is fading

September 27, 2016 4 43pm AEST



https://theconversation.com/science-in-crisis-from-the-sugar-scam-to-brexit-our-faith-in-experts-is-fading-65016

Evidence based policy or its opposite? **PETRUCHIO:** I say it is the moon. **KATHERINE:** I know it is the moon. **PETRUCHIO:** Nay, then you lie. It is the blessèd sun. **KATHERINE:** Then God be blessed, it is the blessed sun.



Shakespeare, the Taming of the Shrew, Act IV.

But sun it is not, when you say it is not,

And the moon changes even as your mind.

The expression 'Policy based evidence' has entered the public discourse.

Warring parties accuse one another of the sin.

"Greenpeace […] wants is policy based evidence making not evidence based policy making" (Sanderson, 2015) …

Wilkes, G., 2015, Free Lunch: Policy-based evidence-making, Financial Times, July 3. Sanderson, A.B., 3 Feb 2015, Breitbart, see <u>http://www.breitbart.com/london/2015/02/03/academic-attacks-greenpeace-for-ignoring-the-</u> <u>evidence-on-gm-crops/</u>; the politician is UKIP Energy Spokesman Roger Helmer MEP. "This need [for evidence] has been reified in the UK and elsewhere, as routines of 'evidence-based policy'making have been hardwired into the business of Government.

[…]such approaches are fundamentally flawed [because] Government […] seeks to capture and control the knowledge producing processes to the point where this type of 'research' might best be described as 'policy-based evidence'."

Boden, R. and Epstein D., 2006, Managing the Research Imagination? Globalisation and Research in Higher Education. *Globalisation, Societies and Education*, 223–236.

Discussion points



• Are we (my team, my organization) into evidence based policy or policy based evidence?

Trust in science, trust in quantification Is science always right? Karl Pearson (a social Darwinist) suggests not wasting resources on social programs as:

"No degenerate and feeble stock will ever be converted into healthy and sound stock by the accumulated effects of education, good laws, and sanitary surroundings"

> THE GRAMMAR OF SCIENCE

> > Ratt Dearson



Karl Pearson



Think Tank Scholar or Corporate Consultant? It Depends on the Day

Acting as independent arbiters to shape government policy, many researchers also have corporate roles that are sometimes undisclosed.

By ERIC LIPTON, NICHOLAS CONFESSORE and BROOKE WILLIAMS AUG. 8, 2016

The New York Times

http://www.nytimes.com/2016/08/09/us/politics/think-tank-scholars-corporate-consultants.html?_r=0

Lobbyists recruit laws firms which in turn recruit scientific services for their customer;

http://www.publicintegrity.org/2016/02/08/19223/meet-rented-white-coats-who-defend-toxic-chemicals



"Nearly half of Gradient's articles that are peer-reviewed are published in two journals with strong ties to industry, *Critical Reviews in Toxicology* and *Regulatory Toxicology and Pharmacology*" [Gradient is the research services company enrolled by law firms]



http://www.publicintegrity.org/2016/02/08/19223/meet-rented-white-coats-who-defend-toxic-chemicals

JAMA Internal Medicine

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Online First >

Special Communication | September 12, 2016

Sugar Industry and Coronary Heart Disease Research

A Historical Analysis of Internal Industry Documents



ONLINE FIRST

Cristin E. Kearns, DDS, MBA^{1,2}; Laura A. Schmidt, PhD, MSW, MPH^{1,3,4}; Stanton A. Glantz, PhD^{1,5,8,7,8}

[+] Author Affiliations

JAMA Intern Med. Published online September 12, 2016. doi:10.1001/jamainternmed.2016.5394

Text Size: A A A

See also https://www.theguardian.com/society/2016/apr/07/the-sugar-conspiracy-robert-lustig-john-yudkin, and the story of US President Dwight Eisenhower heart attack,...

"our findings suggest the industry sponsored a research program in the 1960s and 1970s that successfully cast doubt about the hazards of sucrose while promoting fat as the dietary culprit in CHD [coronary hearth disease]"



Evidence as the currency of lobbies



Sylvain Laurens

Les courtiers du capitalisme

Milieux d'affaires et bureaucrates à Bruxelles





Lee Drutman



Sylvain Laurens

Some quick read: http://www.nybooks.com/articles/2016/04/07/how-lobbyists-win-inwashington/ http://www.contretemps.eu/lectures/lire-extrait-courtiers-capitalismesylvain-laurens

Both works (resp. US, EU) make the point that evidence is the currency of lobbies.

In the use of evidence actors with deepest pockets may prevail. A worrying asymmetry. A truly black pearl: a candid admission in a book <u>written for the lobbyists</u>: The regulation game, Owen & Braeutigam, 1978





<u>Book written for the lobbyists</u>: The regulation game, Owen & Braeutigam, 1978



"This activity requires a modicum of finesse; it must not be too blatant, for the experts themselves must not recognize that they have lost their objectivity and freedom of action"

Owen B. M. and Braeutigam, R., Regulation Game: Strategic Use of the Administrative Process, page 7, Harper Business (1978)
Voices of concern:

"science has taken a turn towards darkness" (Richard Horton, editor-in-chief of The Lancet, 2015)

"Science is turning back to the dark ages" (Phillips, 2016)

"If Donald Trump were to trigger a crisis in Western democracy, scientists would need to look at their part in its downfall" (Macilwain, 2016)

Horton, R., 2015, Comment, Offline: What is medicine's 5 sigma? The Lancet, 385, 1380. Phillips, M., 2016, Science is turning back to the dark ages, Times, March 4. Macilwain, C., 2016, The elephant in the room we can't ignore, Nature, 531, 277. Economics?

The Mathiness discussion in Economics

"The style that I am calling mathiness lets academic politics masquerade as science. Like mathematical theory, mathiness uses a mixture of words and symbols, but instead of making tight links, it leaves ample room for slippage between statements in natural versus formal language and between statements with theoretical as opposed to empirical content."



Paul Romer Since July 18 2016 Chief Economist of the World Bank



Cargo Cult Science

by RICHARD P. FEYNMAN

Some remarks on science, pseudoscience, and learning how to not fool yourself. Caltech's 1974 commencement address.



Appeals to Richard Feynman's famous speech https://paulromer.net/feynmanintegrity/



The Trouble With Macroeconomics

PAUL ROMER Stern School of Business New York University

Wednesday 14th September, 2016

2 Post-Real Models

5.4 Identification by Obfuscation

6 Questions About Economists, and Physicists

7 Loyalty Can Corrode The Norms of Science

9.1 The Norms of Science

10 The Trouble Ahead For All of Economics

https://paulromer.net/wp-content/uploads/2016/09/WP-Trouble.pdf



The Trouble With Macroeconomics

PAUL ROMER Stern School of Business New York University

Wednesday 14th September, 2016

"striking parallels between the characteristics of string-theorists in particle physics and postreal Macroeconomists" A different diagnosis for a diseased economics: for Erik Reinert's: economics has reverted to scholasticism

··· forgetting an important continental tradition

··· implications for developments

http://www.andreasaltelli.eu/file/repository/Full_Circl e_scholasticism_2.pdf







Trust and quantification.





Theodore M. Porter, Trust in Numbers, The Pursuit of Objectivity in Science and Public Life, Princeton 1995

Trust, authority and styles of quantification: two different stories









Porter's story: Quantification needs judgment which in turn needs trust …without trust quantification becomes mechanical, a system, and systems can be played







Discussion points



- Do I see a relationship between trust and quantification?
- Are we (my team, my organization) more like the 'corps des ingénieurs des ponts et chaussées' or the US Army corps of Engineers?

In the next episodes

- PNS Silvio's lecture
- Tools for responsible quantification
 - NUSAP
 - Sensitivity auditing

Course in Bergen March 13-17

http://www.uib.no/en/svt/103559/numbers-policy-practical-problems-quantification#about-the-course

Course in Bergen March 13–17; Numbers for policy: Practical problems in quantification



Andrea Saltelli

Centre for the Study of the Sciences and the Humanities <u>Andrea.Saltelli@uib.no</u>



Ragnar Fjelland

Professor Centre for the Study of the Sciences and the Humanities +47 55 58 32 35 Ragnar.Fjelland@uib.no



Carl Walter Matthias Kaiser

Head of Department, Director Centre for the Study of the Sciences and the Humanities +47 55 58 24 86 +47 917 33 928 <u>Matthias.Kaiser@uib.no</u>



Roger Strand Professor Centre for the Study of the Sciences and the Humanities +47 55 58 34 36 +47 480 74 017 Roger.Strand@uib.no



Silvio Oscar Funtowicz

Adjunct Professor Centre for the Study of the Sciences and the Humanities <u>Silvio.Funtowicz@uib.no</u>



Jeroen P. Van der Sluijs

Professor, Theory of Science & Ethics of the Natural Sciences Centre for the Study of the Sciences and the Humanities

http://www.uib.no/en/svt/103559/numbers-policy-practical-problems-quantification



END

Twitter: @andreasaltelli