



# What is Post-normal Science? A Personal Encounter

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## Abstract

What is post-normal science? What are the reasons for, and consequences of, encountering it in one's professional life? Here I share my own experience of readings, practices and discussions with the fathers, supporters and detractors of PNS. After a short description of PNS and of my own experience with it, I review some common criticism levelled to PNS from different authors and conclude reflecting on how PNS—difficult to explain and translate into formulae or checklists—provides its practitioners with useful keys to open relevant doors to understanding, and might be especially suited to face the present intersecting crises befalling the use of science for policy.

**Keywords** Reductionism · Techno-optimism · Epistemology · Quantification

## 1 Introduction: What is Post-normal Science?

The moment I dread the most in conversations about post-normal science (PNS) is when I am asked, sometimes with a vaguely ironic smile, what this post-normal science is after all. I could reply with the well-known mantra “The sort of science that is needed where facts are uncertain, values conflicting, stakes high, and decisions urgent”. My experience is that a more comprehensive definition of PNS can only be subjective and is best related to personal experience.

Readers will be familiar with the rainbow diagram (Funtowicz & Ravetz, 1993, Fig. 1). It suggests a ‘post normal’ region where the uncertainties are so great and the stakes are so high as to make ‘normal science’ inadequate, perhaps because science is not the best candidate to fix problems that science has itself created (Funtowicz & Ravetz, 1991). Between the normal and the post normal sits a region where the tacit elements of a craft drive the action of a practitioner, such as a surgeon in the operating room or a military commander in a battlefield. The term ‘professional consultancy’ aims to cover these situations, where one is not allowed to sift the course of action through the ordered channels of peer review.

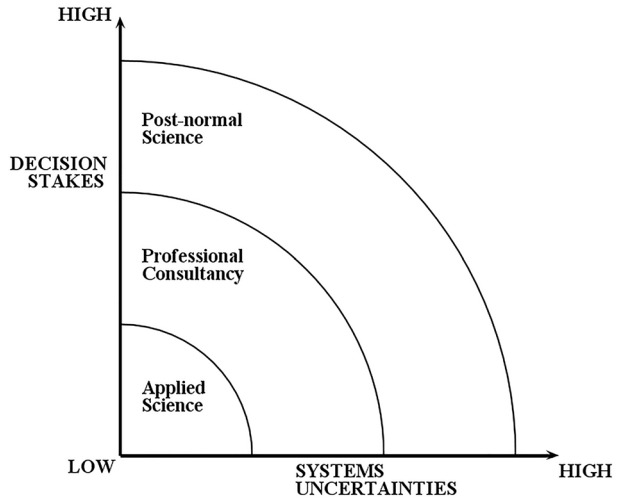
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**Fig. 1** The post-normal science diagram. *Source:* Wikipedia Commons, license CC BY-SA 3.0



Beside these classic definitions, there are some aspects of PNS that are important and that resonate vividly with my own experience.

- *An uncomfortable science.* Since “Science for the post-normal age” appeared in *FUTURES* in 1993 (Funtowicz & Ravetz, 1993), the article was cited more than 6,000 times, according to Google Scholar. Almost three decades later, one would therefore imagine that post-normal ideas are widely accepted. Those familiar with the literature know that instead post-normal science is still deeply irritating, uncomfortable and unwelcome to many; tactics deployed to remove uncomfortable knowledge, such as PNS, are well described by Steve Rayner (2012). A common refrain is that the rise of post-normal science has dampened the internal critical practice of scientific communities while increasing scepticism in citizen communities, see e.g. (Newman, 2018). For others, PNS represents an invasion of the political arena by activist scientists (Wesselink & Hoppe, 2011). More aggressive rebuttals of PNS can be found in web pages such as rationalwiki.org (Post-Normal Science, 2011). This may seem sad to those who endorse PNS, but in another sense, it is comforting, in that the iconoclastic drive of PNS is still active; however, there is still much to be done.
- *A humble science.* Post-normal science is extremely clear in delimiting its applicability to practical and problematic situations, rather than fundamental research—although the fact that science today is no longer little, but big or mega<sup>1</sup> (de Solla Price, 1963), makes it difficult at times to make the distinction. In situations where science is used to deal with plagues, pandemics, social and ecological problems related to our increas-

<sup>1</sup> “Little Science Big Science” is the title of a much-quoted work by historian of science Derek de Solla Price that describes the rapid transformation of science from little to big, also as a result of WWII, and the ‘impossible’ growth in the production of PhD dissertations and journal articles. He hypothesizes that science might succumb under the weight of its own success. This theme was also treated by Jerome R. Ravetz (1971) in his analysis of how the social fabric of the scientific enterprise would change with big and mega science, and how scientific quality control practices would come under strain under these mutated social circumstances.

ing impact on the planet and health, inequalities and human rights violations, the post-normal approach may be seen as natural. So argue a group of experts in complexity (Tainter et al., 2001, 2006) dealing with energy transition scenarios. For these authors, issues involving humans and energy can only be addressed with “a liberal dose of PNS”:

Future energy transformation will involve post-normal science because public interest will be central, and political will may be as limiting as engineering issues [...] Values, uncertainty, urgency, and high stakes all suggest the utility of a post-normal approach to future energy. (Tainter et al., 2006).

On the contrary, perspectives that tend to reduce the complexity of these choices to easy one-dimensional metrics and present these as the stark facts on which politics must act, are the ones that most tragically—often—lead to wrong choices. Several examples could be made here, but I defer the reader to the compendium by Scoones and Stirling (2020), with topics ranging from countries’ flooding insurance, to the securitization of risk, to the regulation of pesticides. One component of the humility of post-normal science is that it programmatically declares itself neither value-free nor ethically neutral (Funtowicz & Ravetz, 1990a): in other words, it renounces the alleged neutrality of the scientific method or knowledge, a claim that is instead characteristic of conservative approaches to the use of science (Harding, 1995; Saltelli et al., 2020a, 2020b; van Zwanenberg, 2020).

- *Few simple keys.* The list of recipes offered by post-normal science is surprisingly short, just as the keys it provides are small compared to the doors they open. One, already mentioned, is the advice not to attempt to separate facts from values. Another key, apparently very simple but difficult to practise, is to be aware of the observer’s position, i.e., a call for reflexivity. The last key, very characteristic of the post-normal approach, is the invitation to gather an “extended community of peers” around a problem. The “extended peer community” is a key point of the theory. It is also a delicate and vulnerable practice: when important interests are at stake, they may colonise the debate; an example described in (Saltelli et al., 2022a) is that of ethicists finding themselves isolated when discussing ethics of artificial intelligence in a room dominated by representatives of the sector. Many translate “extended peer community” as “extended peer review”, which presupposes both a hierarchical structure (someone asks for and receives the review) and the implicit desire for this process to culminate in a consensus—another tool for compression, reduction or simplification in line with the conservative views of the role of science mentioned above. A challenging dissection of the pros and cons of participation and coproduction is offered by Philip Mirowski, (2020).

## 2 Buying into PNS: A Personal Experience

In my *pre*-post-normal life, I used to torture numerical practices used in support of policies to identify their weaknesses and thus make them more robust. Mathematical and statistical models and various forms of indicators were my hunting ground. This activity was criticised by mature post-normalists, who reproached me for being ‘technical’. Well, what’s wrong with being technical, I wondered? My ‘enlightenment’, so to speak, was to realise that my efforts to find the bug inside the model or the indicator *presumed* the model or the indicator itself. I was not asking some seemingly trivial questions: why does this model

exist? Who asked for it? Who developed it? With what funding? With what aims and expectations? What voices were heard at the time of its construction? What are the fundamental assumptions about the nature of the problem addressed, and the vision of what constitutes progress? At any rate, is the model a solution to a real or to a supposed problem? This awakening had also been fostered by many years spent studying and modelling the behaviour of a nuclear waste disposal a million years into the future.<sup>2</sup> These conversations provided me with my first key.

Framing questions are not unique to post-normal science, and are certainly familiar to sociologists of science—one need only read the work of Ulrich Beck (1992), for example—but I doubt that as a scientist trained in natural sciences I would have accessed this kind of sensibility without the intelligent translation work offered by post-normal authors, notably in what are now considered the foundational texts on the subject (Funtowicz & Ravetz, 1990b; Ravetz, 1971). Even accepting the thesis that “the concept developed by Funtowicz and Ravetz is nothing more than the classic issue of sociology of knowledge and actually represents problems characteristic of traditional scientific cognition” (Karpińska, 2018), or that PNS arguments are “old wine in new bottles”, as noted by Weingart (1997)—even then, one has to accept the merits of the extremely effective translation offered by PNS.

Working in a much regulated and decidedly hierarchical institution such as the European Commission, the impact of PNS on my activity was evidently strong. I was mainly concerned with the development and quality control of quantitative tools (indicators, models) used in the design, monitoring and evaluation of policies. The shift from complacency to awareness of glaring contradictions was considerable. To give one example among many, I found myself moving from a technical examination of statistics and indicators of educational systems, to a criticism of the same indicators because of their effects in the power relations between states, regions and international bodies, as well as their negative impact on the systems themselves (Araujo et al., 2017). Many of my best friends being educationalists, this also caused animated discussions; like several other times in my work, the problem was if one should throw out the baby of quantification with the bathwater of its instrumental use, to use Andy Stirling’s (2023) apt simile. In recent years many works have targeted the dystopian aspect of rating, rankings and algorithms (Muller, 2018; O’Neil, 2016), also in the educational arena. I believe this line of work—of which the French movement of stactivists (Bruno et al., 2014) is an excellent example—is worth pursuing (Saltelli et al., 2022b).

As my work involved dealing with quantifications, I was influenced by the post-normal proposal not to produce relevant numbers without an accompanying description of their origin, of a pedigree such as NUSAP (Funtowicz & Ravetz, 1990b). This led me to extend the methodology I had already been working on for decades—sensitivity analysis (SA, Saltelli et al., 2008)—to a methodology open to sociology: sensitivity auditing (Saltelli et al., 2013). A statement about the relevance of PNS can be found right at the beginning of a sensitivity analysis primer I wrote with many collaborators (Saltelli et al., 2008). To many number crunchers in my SA community, this surely appeared eccentric. An expert on social multi-criteria analysis made a similar choice in his volume on the topic, published the same year (Munda, 2008). Perhaps these ‘contaminations’ have been useful to popularize the subject to an audience of non-sociologists of science.

<sup>2</sup> See chapter in (Pilkey & Pilkey-Jarvis, 2009) and the supplementary material provided in (Saltelli et al., 2020a) for a discussion.

In a sense, my interest in PNS was a response to the institutional culture of my organization. Reading, much later in life, the critique of a so-called ‘technocratic orthodoxy’ by sociologist Patrick van Zwanenberg (2020), I can now see why my actions in the organization were met with frequent incomprehension or hostility. Perhaps, rather than openly inviting the institution to become more reflexive (Guimarães Pereira & Saltelli, 2017), I should have better diagnosed the elements of this orthodoxy. For example, I could have questioned the institution’s inclination toward a candid positivism, its deep belief in the neutrality of science, whereby contestation is necessarily the product of ‘special interests’ or ‘deniers’; its desire to support European regulation against the risk of recurring deconstruction of official policies; its entrenched preference for quantification based on risk and cost benefit analyses against the need to question the necessity or possibility of new products or technologies. Unsurprisingly, all these elements are the object of critique by PNS. Reflecting now on the politics of numbers (Saltelli & Di Fiore, 2023), I formed the opinion that there is a political economy of quantification whereby epistemic authority is purchased via recourse to models whose role is to objectify—and possibly sterilize—political issues making them appear determined and solvable through impersonal objectivity. During the recent pandemic, model-based policies have been embraced under the banner ‘follow the science’ (Saltelli et al., 2023). This was achieved by instrumentally ignoring uncertainties in crucial model parameters, as well as the modellers’ bias dictated by their lifestyle and working habits (Winsberg, 2022; Winsberg & Harvard, 2022). The little keys of PNS can change one’s style of work and analysis, and open unsuspected doors.

A line of research triggered by my post-normal acquaintances and readings concerns the integrity of science and the crisis of science in the broadest sense, in its multiple aspects (Moedas et al., 2019; Saltelli & Funtowicz, 2017). This also led to my cooperation with statisticians, looking at the reproducibility crisis in terms of normative and epistemological problems, trying various sociological approaches to interpret the link between science, technology and new communication media, also in relation to the problem of so-called post-truth (Saltelli & Boulanger, 2019; Saltelli & Sarewitz, 2022) and to the issue of science’s integrity (Saltelli, 2023). Sociology and the ethics of quantification were another direction taken in this voyage (Di Fiore et al., 2022; Saltelli & Puy, 2023; Saltelli et al., 2021a). Statistics remained a term of reference for an in-depth discussion of problems linked to mathematical models; indeed, while the discussion among statisticians is animated, that among modellers is almost inaudible. This theme is treated in several articles and a forthcoming book on the politics of modelling (Saltelli & Di Fiore, 2023) that includes relevant PNS contributions.

It should be noted that, as often happens in PNS, these discussions were not always free of controversy. To many listeners, the idea of a science in crisis, or of scientists cutting corners to increase their academic prospects, was an insult, something unacceptable, engendering a reaction along the lines of “We do not do these things here”, or references to ‘bad apples’, or claims that the emergence of non-reproducibility was a proof that science as a system was working properly (Fanelli, 2018). The fact of having published works with PNS contents was enough to defend myself, but not to convince all. When Nature published two articles informing us that the reproducibility crisis could be solved if we all followed the practices of physics, I tried to publish a reaction with some coauthors, but this remained at the preprint stage (Saltelli et al., 2021b). Interestingly, the technical journals did not like our line of argument, while the sociological journals said that these were old, well-known problems, unworthy of publication.

Based on my own experience, I have come to appreciate the keys of post-normal science after having collided with a few closed doors or with some uncomfortable doubts

about the direction of progress brought about by a scientific life. Since science is increasingly confronted with problems where facts are uncertain, values disputed, decision urgent and stakes high—think of the recent pandemic—more than a few susceptible scientists are realizing that perhaps the science that is needed to solve a problem cannot be the same science that created it. With COVID-19, the discussion about PNS became in a sense more imperative, leading a number of us practitioners to draw on its lessons (Saltelli et al., 2023; Waltner-Toews et al., 2020). In retrospect, who can deny the uncertainty of facts, the high stakes, the disagreement over values, and the urgency of decisions to be made? From one day to the next, we have woken up to disagreement among experts, the opacity of mathematical models, the essential inability of international bodies to coordinate efficiently, and the success and failure of different national models, culminating in the non-re-election of President Trump, which is credited by most precisely to his mismanagement of the pandemic (Bennett & Berenson, 2020; Clarke et al., 2021). Far from predicting and controlling events, as in the vision of normal science, we found ourselves plunged into a reality that resists our measures. This is more like a tale by Borges than a discourse of Descartes. As noted in (Waltner-Toews et al., 2020):

*... this pandemic offers society an opportunity to open up a new discussion about learning how to do science differently. [Here] the whole world becomes an 'extended community of peers', as the appropriate behaviour and attitudes of individuals and masses become crucial to an effective response to the virus.*

This work, surprisingly translated in several languages, advocated for a new objectivity, constructed by accepting non-equivalent descriptions and perceptions of our interaction with nature.

Post-Normal attitudes constitute an ongoing challenge to new readings and approaches. One cannot stop at the very few 'foundational' articles (Funtowicz & Ravetz, 1993, 1994), although these are illuminating texts. Accessing a post-normal sensibility implies reading in many directions, from the fathers of ecology to the pragmatists, from relational ecology to the sociology of science, from philosophers who have dealt with scientific thought to the field work of those who, coming from many different disciplines, have found themselves going against the grain in their approach to important problems relating to the environment, health, society and politics. I obviously do not mean that these and exactly these are the sources to draw upon in a systematic exploration of post-normal science. Rather, I mean to say that the latter provides an epistemological, perhaps humbly hermeneutic key to address today's problems. After all, if you don't seek to open doors, you don't need any keys.

### 3 The critique of PNS

PNS has attracted several critiques by defenders of science. In a reply to one of my pieces appeared in *The Conversation* (Saltelli, 2016), Patrick Stokes commented that.

*What worries me is that at some point these discussions can slip into a more ontological relativism that denies the epistemic authority of science—and, by extension, scientists—per se. And carrying that relativism, and the expertise-denialism it licenses, into practical domains has serious consequences. It's the reason we have sections of the public that refuse to accept the urgent reality of climate change, and why we have parents who needlessly expose their children to vaccine-preventable diseases.*

You can find my reply and several others in the Journal. While the concern deserves respect, what's being questioned here is whether it is permitted to challenge the epistemic authority of science, and where this questioning becomes necessary. One could also note that, like in Ibsen's play *The Enemy of People*, it is almost a rule that the best intentions inevitably lend themselves to distortion and manipulations. Supporters of the ex-president Trump may argue (Haberman et al., 2023) that it "has been proven time and again he is the only person who *will speak truth to power*" (my emphasis). This does not lead us to blame Mahatma Gandhi for coining the expression. The fathers of PNS were presciently aware of this risk—and of the danger that PNS could be perverted before its full innovative potential could come to be realized (Funtowicz & Ravetz, 2023).<sup>3</sup>

## 4 Conclusions

It is important to be aware that progress is excruciatingly incremental. The scientific community is still very polarised and divided. The dialogue between what are called the great families of science (Crowe, 1969)—the natural sciences on the one hand, the social sciences and humanities on the other—is still plagued by tenacious religious wars. Many who have never read a so-called postmodern author claim that postmodern thought has poisoned the purity of science by introducing an element of relativism, which is always accompanied by the adjective 'absolute'. For them, as discussed above, post-normal science is yet another contraption of the sowers of doubt. To the extent that a post-normal attitude invites critical reflection and openness to dialogue, it becomes the enemy of consensus, which on hot topics in science, from climate change to genetically modified organisms, must always be total. In these contexts, an overtly post-normal attitude can be dangerous, especially for researchers at the beginning of their careers who cannot afford the luxury of alienating the consensus of their senior peers in the discipline.

Will society adopt this different way of doing science? The polarization of the debate on how to tackle the pandemic is not encouraging, nor is the similarly polarized debate on the origin of the virus (Pielke Jr., 2023; US Senate HELP Committee, 2022). It is imperative to reflect on the aspects of global governance, including scientific governance, that made the crisis possible and the solution difficult, despite the success of pharmaceutical technology that allowed the production of billions of vaccine doses in an unthinkable short time for use in the rich developed North (Saltelli et al., 2023).

In the post-normal reflection of (Waltner-Toews et al., 2020), myself and the other authors call for a new covenant between science and society, one less reliant on a top-down model of science decision-making and communication, far from the intimations to "follow the science" that –we argued—did more to alienate than to convince. The experiment is ongoing.

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<sup>3</sup> The theme of a possible perversion of a critical science (later to become PNS) is treated extensively in (Ravetz 1971, pp. 427–428).

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## Declarations

**Conflict of interest** The corresponding author states that there is no conflict of interest.

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