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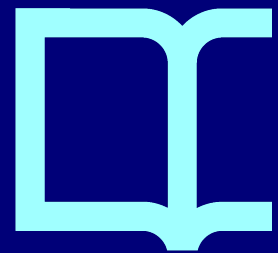
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**Post-normal science 30 years on. Editorial Introduction: Ongoing conversations about knowledge, science practices, integrity and quality through Post-Normal lenses.**

Zora Kovacic <sup>a,b\*</sup>

Annibale Biggeri <sup>c</sup>

<sup>a</sup> Estudis d'Economia i Empresa, Universitat Oberta de Catalunya, Rambla del Poblenou 156, 08018 Barcelona, Spain

<sup>b</sup> Centre for the Study of the Sciences and the Humanities (SVT), University of Bergen, Parkveien 9, 5007 Bergen, Norway

<sup>c</sup> Dipartimento di Scienze Cardio-Toraco-Vascolari e Sanità Pubblica, Università degli Studi di Padova, via Loredan 18, Padova, Italy

\* corresponding author: zkovacic@uoc.edu

This special issue marks the 30<sup>th</sup> anniversary since the publication of the article entitled “Science for the post-normal age” in *Futures* in 1993, by Silvio Funtowicz and Jerome Ravetz. The article crystallised the term post-normal science, which Funtowicz and Ravetz had previously referred to as “total environmental assessment” (Silvio Oscar Funtowicz & Ravetz, 1985) and “second-order science” (Silvio Oscar Funtowicz & Ravetz, 1991). The concept of post-normal science (PNS) has since inspired emerging research fields, including ecological economics (Funtowicz & Ravetz, 1994; Martinez-Alier, Munda, & O’Neill, 1998), citizen science (Irwin, 1995), sustainability transitions (Loorbach, 2014; Loorbach & Rotmans, 2010), degrowth (D’Alisa, Demaria, & Kallis, 2014) and it has influenced researchers working in a variety of different fields, including epidemiology (Waltner-Toews et al., 2020), genetics (Brossard, Belluck, Gould, & Wirz, 2019), toxicology and bio-ethics (Tallacchini, 2005). According to (Kaiser & Gluckman, 2023; McGregor, 2013) post-normal science has been very influential in the development of transdisciplinarity. Post-normal science has also contributed to policy thinking in European institutions, informing landmark reports such as “Late lessons from early warnings”, published by the European Environment Agency (EEA, 2001, 2013), informing the work of the Netherlands Environmental Assessment Agency (Petersen, Cath, Hage, Kunseler, & van der Sluijs, 2011). The Joint Research Centre of the European Commission organised the second Post-Normal Science Symposium in 2016. Thirty years later, the 1993 article continues to be the most cited article of *Futures*, with 2630 citations according to Scopus and 6027 citations according to Google Scholar (as of January 2023).

One may argue that due to the increasing number and frequency of crises the world is facing (environmental, financial, health, climatic, energy-related and recurrent wars including in Europe), we are living more than ever in a post-normal age, characterised by irreducible uncertainty and high stakes. But post-normal science is about being contextual, it emerges from a critique of the vision of science as the pursuit of some sort of out of time truth. So, it is necessary to keep reflecting on science, its practices and its relationship with governance during the present time. Which times are we living in

now? What are the challenges to science now? Is post-normal science still a valid approach, does it need to be updated? How has it evolved? And how does post-normal science relate to other fields and approaches that have emerged since the 1990s? By engaging with this and other questions, this special issue aims to give an overview of some of the latest contributions that further develop the post-normal science conversation.

Are we still living in a post-normal age? The COVID pandemic can be seen as a textbook example of post-normal science. Scientific uncertainty, the limits of scientific knowledge and its methods, and the contradictions within science became evident to the public eye during the pandemic. It became clear that science does not speak with one voice, and science advice to government varies. Some governments even changed strategy during the pandemic. Decisions have been made quickly, before knowledge of how the virus spread was in, before vaccines were developed, before the effects of vaccines could be studied exhaustively. The pandemic was also a shock to many who expected, or hoped, that science would provide answers and guidance to decision-making, rather than being unable to diminish the chaos (if not part of it). In this sense, speaking of a post-normal age may be a good diagnostic but not a desirable situation (Kovacic, 2022). The marches for science (Motta, 2018) that followed the election of Trump in 2016 and their defence of a very specific concept of science as provider of unquestionable truths, are a sign of the discomfort of post-normal times. What may emerge is not an opportunity for other ways of thinking about science to gain ground but a longing for the idealised science, the one that provides control, that eliminates uncertainty, and that takes away the discomfort of difficult decisions.

In this context, new challenges arise to science and to post-normal science. Numerous scholars have documented the crisis of science (Ioannidis, 2005; Saltelli & Funtowicz, 2017). Ravetz (2022) notes that science is undergoing internal and external crises: internally with respect to the irreproducibility crisis, which counters the belief in the integrity of scientists and of science as an institution, and the proletarianisation of science, which makes researchers part of the gig-economy. Externally, the crisis is manifested in the populist rejection of expertise and the post-truth phenomenon. Both crises undermine trust in science. With regard to the future of science, Ravetz (2022) observes the emergence of a new phenomenon, where the very existence of a scientific debate is challenged by one of the sides, as is the case of debates about climate change or vaccines. Taking the example of the Intergovernmental Panel on Climate Change, priority is given to reaching consensus, perhaps feeding into the denial of scientific debates. An alternative approach is that taken by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, which has put epistemic pluralism and value disputes at the core of its functioning (IPBES, 2022). From a post-normal science perspective, it is important to be able to disagree well.

Ravetz (2022) asks: can post-normal science restore morale and morality in science? The answer to this question is very difficult. In a context of crisis, there is the risk of an instrumental and disingenuous use of the insights of post-normal science to fit with different agendas, much like the overselling or underestimation of uncertainty described by Oreskes and Conway (2010) in *Merchants of Doubt*. Post-normal science is not the science of post-truth. In the case of the covid-19 pandemic, the inescapable uncertainty with regard to the spread of the virus, its evolution in different variants and its cures, is not to be confused with a *carte blanche* for sloppy science. Post-normal science is not an invitation to forget the science, it is a call for a collective reflection about the role of science. As Giatti (2022) argues, in the polarising environment created by post-truth stances that discredit science on one hand and on the

other hand the perceived need to defend a positivist (and possibly outdated) view of science, post-normal science could offer an alternative, by integrating rather than weaponising uncertainty in science. For this ideal to be realised, Ravetz argues in the first article of this collection, there is still work to do.

The contributions of this special issue offer some tentative solutions to this dilemma, derived both from practical experience and theoretical considerations. Reflecting on the practice of post-normal science, De Marchi, Ficorilli and Biggeri (2022) discuss how one can move from the idea of participatory governance to its practical implementation, based on the application of the concept of extended peer community (EPC) to an epidemiological study in Valle del Serchio, Tuscany, Italy. The case study is an example both of a post-normal science-inspired approach to the assessment of environmental pollution from an industrial source and its relationship to a variety of diseases, and of how post-normal practices may work during post-normal circumstances, since the research unexpectedly took place during the COVID-19 pandemic. De Marchi et al. highlight aspects that worked particularly well, such as the spontaneous creation of a citizens committee, which facilitated dialogue between the researchers and the local administration, and the initiative of citizens to set up out-patient clinics to respond to the restriction created by the COVID-19 pandemic.

Theoretical contributions highlight that part of the work that needs to be done in post-normal science is to consider more in-depth questions of power in extended peer communities. Strumińska-Kutra and Scholl (2022) argue that post-normal science and transdisciplinary research more in general, lack effective capabilities for detecting and coping with power dynamics. They identify three types of power-related challenges: (i) the cultural, institutional and social environments that uphold specific (positivist, neutral, independent) ideals of what science is may be hostile to participatory processes that challenge legitimised ways of doing science, (ii) power asymmetries within the extended peer communities, may reinforce the *status quo* by giving hegemonic knowledge and solutions a more democratic face, and, (iii) the power of the researcher themselves needs to be scrutinised, by promoting reflexivity. Keeping with the tradition of post-normal science as a conversation, these challenges pose a series of open questions about the practices of science: Should transdisciplinary researchers build socio-political support for their project? Should researchers act as inclusiveness advocates to counter power asymmetries in the extended peer community? What is the role and power of the researcher?

The question of power is relevant also to the inclusion of different types of knowledge in the extended peer communities. Meisch, Bremer, Young, and Funtowicz (2022) explore ways to include tacit knowledge in decision-making processes related to climate change. Tacit knowledge resists being made explicit in words and numbers and poses the challenge of how to elicit this type of knowledge and how to integrate it with other knowledges. Meisch et al. identify four challenges and four strategies for dealing with them. Tacit knowledge is hard to communicate and eliciting tacit knowledge may take a long time, for example through participant observation, hence decisions should be always considered provisional and open to revision. Tacit knowledge is hard to represent in words and numbers, therefore hybrid forms of knowledge are called for that allow for different representations. Eliciting tacit knowledge may make it susceptible to appropriation, which can be countered by paying attention to power, seeking epistemic justice and democratisation of knowledge. Finally, there is the challenge of assessing tacit knowledge that escapes standard languages of valuation. This challenge can be met by fostering interaction and shared responsibility for knowledge production, which build on dialogue and mutual trust.

Giatti (2022) continues the conversation about integrating different types of knowledge while dealing with power asymmetries. He suggests taking inspiration from Freire's work on the pedagogy of the oppressed. Integration of uncertainty in science can be achieved through participatory processes that establish a dialogical relationship between participants, in which the marginalised are seen as knowledge holders. The hegemony of scientific knowledge, however, makes the establishment of more symmetric relationships difficult and translations between lay and expert knowledge remain rare. Sharing power between researchers, decision-makers and "the public" (sic) makes participatory research unpredictable and adaptive, as researchers do not have control of the process. For dialogue *à la* Freire to be achieved, Giatti argues that researchers need to cultivate reflexivity and humility, joining the reflection about discretion by Zaoui (2013).

To be able to disagree well, Ravetz (2022) argues that it will be important to further integrate the complexity perspective in the post-normal science theoretical framework and the understanding that there is no privileged perspective. Kovacic and Benini (2022) continue this conversation by reflecting on the challenges of integrating complexity in science advice to policy, by taking the European Environment Agency (EEA) as their case study. They identify three challenges: (i) taking complexity seriously means recognising the limits of govern-ability of evolving and adaptive systems; (ii) the lack of a privileged perspective makes the possibility of authoritative scientific advice very fragile; and (iii) in a context of high uncertainty due to irreducible complexity, 'solutions' and policy recommendations can only be partial and imperfect. Integrating complexity puts the EEA in an uncomfortable situation as a knowledge broker. The result is that the innovative and disruptive insights of complexity are very much nuanced when it comes to policy recommendations. Part of the transformative power of these concepts is lost through the balancing of opposing institutional needs.

Institutional challenges are another recurrent topic of conversation. De Marchi et al. explain that the involvement of local residents in the epidemiological study of Valle del Serchio raised a number of challenges: (i) ethical clearance for the collection and handling of biological samples had to be extended to citizen scientists, as existing protocols do not contemplate the participation of anyone but medical experts; (ii) it was unclear who was responsible for ethical clearance, as the Medical Ethics Committee did not recognise the co-creation nature of the study as being of their competence (see also Ficorilli, 2022); (iii) the interpretation of possible results and their policy implications had to be designed and discussed before the study was concluded, to "enhance trust between local institutions and the community of citizens, who are often suspicious that the former will attempt to distort the interpretation of the study results to back predefined policy choices" (De Marchi et al., 2022: 6).

The final two contributions of the special issue reflect on how PNS relates to other fields that have emerged since the 1990s. One such field is citizen science, which can be said to have co-evolved with post-normal science. Haklay, König, Moustard and Aspee Quiroga (2023) discuss the relationship between citizen science and post-normal science. Citizen science has grown in popularity since the 2000s, attracting the attention of scholars and inducing a high number of typologies that aim at making sense of different types of activity, degrees of involvement, motivations, aims and technologies through which the public takes part in science and knowledge production. The authors show how the three zones of post-normal science can help make sense of the different types of citizen science. At the same time, they offer a critique of the notion of extended peer community as too generic. They argue that the diverse typologies of citizen science can help nuance the idea of extended peer-community. Hence, post-normal science too stands to learn from citizen science scholarship. Haklay et al. observe that

citizen science activities can be found in all three zones of the post-normal science framework, with the majority of initiatives falling under the “normal” applied science and professional consultancy zones. This is due both to challenges in funding of citizen science projects and to the lack of acceptance of the general public’s role in science. The authors conclude that it is not enough to open up the knowledge production process to others, but it is also necessary to identify the cultural and technical challenges of collaborating with wider groups, resonating with the contributions by Giatti; Meisch et al.; Strumińska-Kutra and Scholl.

Pasetto and Innocenti Malini (2022) enter in a conversation with the US school of environmental justice, which has its roots in the observation that poor communities and ethnic minorities have historically had greater exposure to environmental contamination. The authors argue that if community participation is to be a means for correcting such injustices, communities must be empowered by strengthening their capacities. The authors argue that environmental public health research focuses on developing the knowledge capacities of communities. A series of examples is presented showing the potential of community theatre to create other capabilities such as: a better understanding of communities’ histories, the sense of belonging to a community, critical reflection, networks, leadership, facilitation and communication skills, and fostering participation.

As a closing remark, we note that the articles of this collection are a selection of some of the papers presented at the 5<sup>th</sup> Post-Normal Science Symposium, entitled Knowledge, Science Practices and Integrity: Quality through Post-Normal Science Lenses. The authors do not speak with one voice and some of the appreciations may now be outdated since the context of writing (articles were drafted between 2021 and 2023) may have been different from the context in which now the articles are read. This is post-normal science too, a plural, situated and evolving conversation, which tries to make sense of and adapt to its context. The pandemic converted the 5<sup>th</sup> Post-Normal Science Symposium that was supposed to take place in Florence in 2021, into an online event (the videos of the recorded presentations can be found here: <https://www.youtube.com/@pns5digitaljourneyvideos712>). This experience adds its own nuances to the concept of having a conversation, as the video-presentations of the Symposium are potentially accessible to a larger audience yet the lack of face-to-face interaction makes it more challenging to nuance one’s message or one’s interpretation. Ravetz (2022) argues that post-normal science has become a reform movement. Sometimes reforms fail and the institution (in this case, science) collapses, sometimes they turn into revolutions and sometimes they succeed. If the post-normal reform is to succeed, Ravetz argues that commitment to integrity is key.

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