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Post-normal Institutional Identities

Quality Assurance, Reflexivity and Ethos of Care

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Highlights

- Given the current crises of legitimacy and quality in mainstream science, institutions that produce and govern science and those that provide scientific advice to policy need to change their modus operandis; we advocate for an ethos of care.
- Post-normal science and other frameworks of scientific knowledge production may inspire trustfulness in institutions that provide scientific advice to policy
- In Europe, the Joint Research Centre of the European Commission has the necessary scaffolding to advise policy in view of public interest, but the important actors of change i.e. the scientists themselves and their institutional counterparts, need to be firmly committed to change
- Emerging ways of knowing need to be integrated with mainstream institutionalised science

Abstract

This paper suggest adopting a 'post-normal science' (PNS) style and practice in scientific advice, and motivate the urgency of this methodological stance with the increasing complexity, and polarisation affecting the use of science-based evidence for policy. We reflect on challenges and opportunities faced by a 'boundary organisation' that interfaces between science and policy, taking as example the European Commission's Directorate General Joint Research Centre, whose mission is stated as that to be the "in-house science service". We suggest that such an institution can be exemplary as to what could be changed to improve the quality of evidence feeding into the policy processes in the European Union. This paper suggests how an in-house culture of reflexivity and humility could trigger changes in the existing styles and methods of scientific governance; at the JRC, taken as example, this would mean opening up to the existing plurality of norms and styles of scientific inquiry, and adopting more participatory approaches of knowledge production, assessment and governance. We submit that the institutional changes advocated here are desirable and urgent in order to confront the ongoing erosion of trust in 'evidence based policy', anticipating controversies before they become evident in the institutional setting in which institutions operate.

Keywords: post-normal science, quality, scientific advice, policy, trust, reflexivity, ethos of care

> *"The requirement for the "sound science" that is frequently invoked as necessary for rational policy decisions may affectively conceal value-loadings that determine research conclusions and policy recommendations. In these new circumstances, invoking 'truth' as the goal of science is a distraction, or even a diversion from real tasks. A more relevant and robust guiding principle is quality, understood as a contextual property of scientific information. (…) In those circumstances, the quality assurance of scientific inputs to the policy process requires an 'extended peer community', consisting of all those with a stake in the dialogue on the issue."* (Funtowicz and Ravetz, 1990).

1. INTRODUCTION

This paper examines the need for a new identity for science/policy boundary institutions, i.e. those types of organisations which meet "*three criteria: first, they provide the opportunity and sometimes the incentives for the creation and use of boundary objects*[3] *and standardised packages; second, they involve the participation of actors from both sides of the boundary, as well as professionals who serve a mediating role; third, they exist at the frontier of the two relatively different social worlds of politics and science, but they have distinct lines of accountability to each*" (Guston, 2001). We take as example, the European Commission's Directorate General Joint Research Centre (JRC), which as we shall argue neatly fits these criteria, with its role as mediator of scientific input to policy, i.e. supplying at request of the other European Commission (EC) services the scientific knowledge that may support the policy making cycle. The JRC appears as an example of a 'boundary institution" and it is as such endowed with a unique role within the EC itself. In order to respond to present societal challenges the JRC needs to make choices and adopt styles of analysis, which are congruent with this role.

The JRC is not an institution that *promotes* policies as the OECD does; it is not a research and educational institution like a University or an institution that conducts research "to benefit private and public enterprise" as e.g. the Fraunhofer Institutes are. The JRC is a

[3] I.e. information or knowledge that is used in different ways by different communities and networks. This concept was introduced by Star and Griesemer (1989).

Directorate-General of the European Commission that operates at a crossroad of intertwined political, societal and business spheres. Historically, it developed first as a 'joint nuclear centre', following the signature in 1957 of the European Atomic Energy Community (EURATOM) treaty by the six founder European countries.

As discussed in detail elsewhere (Guimarães Pereira & Saltelli, 2014) the JRC has been developing since the early 1970s to embrace more and more fields of research following the societal challenges of the time, putting the acquired expertise at the service of external actors. For the sake of the argument that we try to develop here it is interesting to look at 2 mission statements of the JRC a decade apart (see Box 1.1). Whilst the overall mission remains unchanged, and independence is maintained as a core value, one can see some interesting changes. For example, the "customer-driven" approach of the early 2000s is substituted by a unique customer: the policy directorates general (DGs) of the EC. The JRC still collaborates with member states (MS) but the focus of the 2013 mission statement focused on the cooperation with policy services of the EC.

The JRC has been addressing pressing societal and policy issues while adopting the narratives of the time, which included authority, control, prediction, independency, objectivity and neutrality of science and science-advice to policy. The changes in the JRC mission reflect the gradual self-attributed role of independent advice, as well as its quest for consensus via its work on standardisation, reference methods, tools and laboratories.

Several models have been proposed for the relation between science and decision-making in policy processes. Funtowicz (2006) offered an evolutionary perspective of the governance of science in policy making through several stages and styles. His account starts from the assumption of scientific perfection and human perfectibility (the Modern model) to progressively incorporate elements of doubt and reflexivity such as, *precaution* (Precautionary model), *stakeholder perspectives* even in the choice of the "problem" (Framing model), *demarcation* as science can be abused when used as evidence in the policy process (demarcation model) - see Chapron, 2014 and Goldacre, 2012 - and *extension* to what counts as relevant knowledge by involving an "extended peer community" (Extended participation model) - see Funtowicz and Ravetz, 1990.

The history and the mission statements of the JRC suggest that the institution has remained firmly attached to the vision of the modern model, i.e. "the experts' *(desire for)* truth speaking to the politicians' *(need for)* power" (Wildawsky, 1979). The JRC hardly engages at all with the public in policy formulation, neither through its mission nor through its operation. At the EC, institutionalised forms of public engagement are

implemented by policy DGs through mechanisms such as the portal 'Your Voice', and the inclusion of civil society organisations in committees and task forces, which are part of the EC's impact assessment practices. Although these activities have some value for the policy cycle, they remain confined in their actual function of consultation reaching out very small numbers of European citizens. Recently, the "European initiative" provides a further mechanism of citizenry involvement in European policy (http://ec.europa.eu/citizens-initiative/public/); projects such as "Voices" (http://www.voicesforinnovation.eu) have been showcasing the value of other types of participatory practices. The recently proposed package for 'Better Regulation Package' (SWD(2015) 110 final) is still in progress, leaving space to inquire about changes in the engagement of wider sectors of society, in particular the citizens of the EU, in policy affairs of the EC.

In 2014 JRC produced a technical paper suggesting a new identity to respond to the on-going crisis of both science and the science advice (Guimarães Pereira & Saltelli, 2014; Benessia et al., 2016). The brief also suggested to foster the fields of science and technology studies (STS) as an engine of internal reflexivity, and post-normal science (PNS) as elements of that identity. In fact, a recent review of the JRC operation (Cunningham et al., 2015) recommended that the JRC acts to improve interdisciplinary research and involves social scientists in every thematic area.

In this paper, we move from the brief to argue that there is momentum for the JRC to seek for a new identity, starting from critically and reflectively examining the original meanings of its assigned mandates of authority, neutrality and independence. We will first offer a brief overview of the recent changes, on-going tensions, and public debates on science practices, science governance and scientific advice to policy making. We next suggest how to move beyond the status quo, with a view to transform the present crisis of science and science advice into an opportunity for the organisation. In particular, we suggest that changes based on a greater role for societal inquiry such as the post-normal science framework, is appropriate for cases where "facts are uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz & Ravetz 1992, 251–273).

In our view, PNS-inspired ideas of quality assurance of science informing policy making would make justice of JRC's uniqueness within the EC and within the EU.

2. Current Challenges for Policy relevant Science

It has been argued that a defining element of modernity is the relation between science and power, with the former offering legitimacy to the latter. This privileged place of science

stems from an eighteenth-century dream of science as a rational solution to practical and social problems and has been intertwined within political discourse for a long time (see e.g Vannevar Bush's "Science The Endless Frontier" in 1945). The dream and its consequences have been the subject of considerable debate and critique in the twentieth century, after thinkers such as Husserl, Kuhn, Toulmin, Lyotard, Feyerabend, Lakatos and many others questioned the (requested) role of science to generate truth and resolve political disputes.

In order to put the role of a boundary institution such as the JRC in perspective a short overview of a huge amount of scholarship on the conflicting role of science with policy is necessary; however, we cannot condense here a century of epistemological disputes, so we will focus on current challenges that affect science and scientific advice to public policy from the contained perspective of a boundary institution.

2.1 Elements of an announced crisis

Ravetz (2016) has recently noted that there is no shortage of proposed remedies to many of the defining elements of what appears as a 'crisis' of legitimacy in the scientific endeavour: reproducibility, abuse of metrics and peer review. The announcement of a 'crisis' of legitimacy is not new (see Ravetz, 1971; Lyotard, 1979). More recently, many authors have described this state of affairs as a crisis of *creativity* (Le Fanu 2010; Strumsky et al., 2010) and of *quality* (Ioannidis, 2005; Mirowski 2011). The JRC has contributed to this reflection with a recently published book on the root causes of science's crisis (Benessia et al., 2016; Saltelli and Giampietro, this issue).

The scientific community has long portrayed its endeavour as self-regulating, bound to a higher ethical commitment to truth-telling than society as a whole. Yet the tone and intractability of present controversies suggest that society may be less willing to accept such claims than in the past. We have noted an increasing number of critical pieces on key academic journals (see e.g. editorials of *Lancet*, 2015; *Nature*, 2015), full projects on research integrity[4] and literate media (such as The Economist, The Guardian, and many others) that address this issue and its multiple manifestations.

The issue of reproducibility in particular, has been subject of a myriad of recent publications and projects (Ioannidis 2005; 2014; The Economist 2013, 2014; Horton 2015; Baker, 2016; Goodman *et al.* 2016); concerns about reproducibility have permeated many fields of science (Begley & Ellis 2012; Begley 2013; Begley & Ioannidis, 2015); published results of laboratory experiments cannot be trusted without verification

[4] See http://www.wcri2015.org/

(Sanderson 2013); Begley (2013) talks of "*suspected work […in] the majority of preclinical cancer papers in top tier journals*". Peer review has equally been under scrutiny for a long time; in 2015 the publisher Springer and the Université Joseph Fourier released SciDetect, a software to discover false scientific papers generated by algorithms (Springer, 2015). Scientists are also often chased by predatory publishers who charge authors for publishing without providing any control or peer review; the shift to digital publications, which has not been accompanied with collectively agreed new ways of quality assurance is playing an important part. Ravetz (2016) noted how the substitution of a 'Gemeinschaft' by a 'Gesellschaft' has brought about dramatic changes in the old system of rewards and sanctions. The abuse of metrics to describe performance as well as the vagaries of the publications business (Ioannidis, 2014; Jump, 2015; Wilsdon, 2014; Callaway, 2016; Miedema, 2016; etc.) - which rely on arguable metrics to qualify journals, researchers and their writings, put inadequate and even corrupting pressures on researchers to publish at all cost; the rise of retractions of scientific papers is seen with increasing concern (Van Noorden, 2011 and the site: http://retractionwatch.com/). We also live in times where the media openly challenge trust in science (Monbiot, 2013) and norms associated to the scientific endeavour are under concerned scrutiny (Jasanoff, 2013).

The key message in Ravetz (1971) is that science is a social endeavour. Thus as the societal and political change and science moves from little to big or mega science the received notions of quality assurance become inadequate. In turn quality assurance norms and practices reflect and determine the knowledge production systems.

According to historian Philip Mirowski, one of the consequences of having adopted neoliberal policies and a neoclassic stance in economics since the eighties has been a massive privatisation of research. For this author this has led to a corruption of the self-governance method of science, and would be now jeopardising the very mechanism of science driven innovation (1991; 2013). In his 2011 book 'Science-Mart: Privatizing American Science' he argues inter alia that commoditised science loses quality. Since the 1980s research has moved away from government laboratories and large research laboratories of major corporations and universities into contract research organisation (CRO) acting under budget pressure and short time horizons. In his recent piece in the newspaper *The Guardian*, Ravetz (2016) includes this change in paymasters – when market replaces 'Gemeinschaft' - among the root causes for quality decline, aggravating the existing epistemological and legitimacy challenges.

Another relevant issue that interests this discussion is ethics. The discussion of ethics in science and technology realms has largely been in the hands of professional communities. Yet the failures of the scientific community's *ethos* in respecting individuals in research

during World War I (defined as "the chemists' war" for the use of poisonous gas – Ravetz, 1971, p. 38), the role of statistical science in upholding eugenics (Hacking, 1990), the use of humans in experiments in World War II (US Holocaust Memorial, 2015), as well as the systematic enrolment (and justification) of science (best described as techno-science) into the production of ever new environmental challenges, has been giving ethics an increasing pro-active role in addressing values challenges arising from techno-science developments.

Uncertainty is at the core of the discussions of quality in science; its amplification or minimisation are standard practices operated by different actors to either support (minimising uncertainties) or deter (maximising them) the adoption of a policy (Saltelli *et al.*, 2013). Famous cases of uncertainty fabrication are tobacco companies fighting to deny the health effect of smoking (Oreskes & Conway, 2010), and the battles between industry and regulators over the USA's data quality act, where industry fought hard to amplify uncertainty in order to prevent regulators from imposing more stringent standards (Michaels, 2005). As discussed earlier, scientists may themselves encumber the public debate with an extra doses of conflict and animosity, making controversies less amenable to a solution (Sarewitz, 2004).

These types of problems are crucially important to both the epistemological and social practices of science. They are also equally relevant to quality assurance of scientific knowledge used for policy, especially when science is mandated by policy circles to answer questions that could be poorly framed. The 'quality assurance' being referred to here is not just about excellent, replicable and publishable scientific outcomes, but more importantly – following a post-normal science line of argumentation, about research framings, agendas, questions, assumptions and outcomes that are adopted by researchers to address societal concerns, including the very question of whether the matters of concern are scientific at all. From this perspective, issues of framing in science deserve outmost attention here, not least because boundary institutions like the JRC can play a role as a space where these views are aired.

Framing of issues in narrowly scientific terms can amount to what is described as "Type 3 error" - i.e. the error of answering the wrong question - or what Lakoff (2004; 2010) described as "hypocognition", i.e. the use of framings to orientate the debates as well as knowledge production within desired normative orientations, or also what Ravetz (1986) and Rayner (2012) described as "socially constructed ignorance" – i.e. the forced simplification of a complex issue into a simplistic narrative.

If the narrative is misplaced and the question is wrong, the supporting evidence is irrelevant. An issue may be framed as one of 'risk' of a technology when the concern of

the citizens is about whose technology is adopted and why, and who governs it. Scientific framings do not necessarily resolve socio-political controversies though they may appear desirable and convenient to some of the interested parties. Through a number of examples from climate change, genetically modified foods and nuclear waste disposal, Sarewitz (2004) described the exacerbation of controversy through *scientised* framings that misrepresent the actual divisive issues. We note that it is a common practice to seek (through at times paternalistic approaches) a model – be it behavioural, psychological or cultural - to explain why is it that the public dissent (Winner 1989; Wynne 1993). This can also justify overt attempts to manipulate public and media opinion to counteract dissent and disengagement. We have witnessed several times that when strong dissent exists, but stakes are high, not all perspectives have the same legitimate voice (e.g. on GMOs, the Internet of Things); the issues chosen to be heralded by media, companies and sometimes governments are often impoverished accounts of the full range of perspectives available in society. For example, proponents of GMOs observe that citizens' hostility to GMOs is at odds with the evidence that GMOs do not have negative health effects. According to the results of a EU-funded study (Marris et al., 2001), food safety was not prominent in the list of citizens' concerns on GMOs. A list of concerns registered by Marris and colleagues includes, *"1. Why do we need GMOs? What are the benefits? 2. Who will benefit from their use? 3. Who decided that they should be developed and how? 4. Why were we not better informed about their use in our food, before their arrival on the market? 5. Why are we not given an effective choice about whether or not to buy and consume these products? 6. Do regulatory authorities have sufficient powers and resources to effectively counter-balance large companies who wish to develop these products?"*

Another example is what Bittman (2013) described as an exercise of misdirection on organic foods. The study (see Smith-Sprangler et al., 2012) focuses on a trivial aspect of the organic versus conventional comparison, i.e. the poorly defined "nutritious" aspects of organic food, while that is not the primary reason why people acquire organic food.

Even issues where once upon a time a linear model of input from science to policy seemed possible have become 'wicked' (Rittel & Webber, 1973) implying that they are deeply entangled in a web of hardly separable facts, interests and values. This applies to GMOs, climate, bees and pesticides, shale gas *fracking*, and many others.

Framing is about what is chosen to sustain an argument, including the types of knowledge produced and mobilised for policy making or simply profit; hence, we must allude here to another longstanding issue: numbers.

> "*the appeal of numbers is especially compelling to bureaucratic officials who lack a mandate of popular election or divine right; scientific objectivity thus provides an answer to a moral demand for impartiality and fairness; is a way of making decisions without seeming to decide*." (Porter 1995).

Many authors (Sarewitz et al. 2000; Pilkey & Pilkey-Jarvis 2007; Giampietro & Saltelli 2016) have extensively looked into numbers produced as indicators and/or by statistical and predictive models across different fields in the context of 'evidence based' action. In Guimarães Pereira et al. (2015) the reader can find a number of examples of what is described as hypocognition and "socially constructed ignorance" (Giampietro in *Op. cit.*) as symptoms of intentional or naïf assumptions and simplifications of complex issues, namely in the energy, food and agricultural sectors (Giampietro; Ravetz; van der Sluijs in *Op. cit.)*; the confounding of scales of analysis when using quantitative information (Giampietro; Kovacic in *Op. cit.)*; serious misconceptions about probability leading to "quantifauxcation' (Stark in *Op. cit.*); the lack of social robustness of indicators and models used to deal with complex societal issues (Denkel in *Op. cit*); the significance of quantitative information in a plurality of perspectives where different sources of credibility and legitimacy are at stake (Kovacic in *Op. cit.)*; assumptions in foresight models for which there can never be knowledge to support (Kay in *Op. cit.)*; realisation that quantitative information embeds narratives and disciplinary perspectives that represent selective representations of reality (e.g. Saltelli in *Op. Cit.*).

The discipline of economics is especially prone to deliver motivations and justifications for not so happy endings for citizens. Harvard professors Kenneth Rogoff and Carmen Reinhart calculated a threshold of 90% for the ratio of public debt to gross domestic product, above which countries' economic growth would supposedly be impaired. A subsequent re-analysis by researchers from the University of Massachusetts at Amherst disproved this finding by tracing it to a coding error in the authors' work. However, this revelation did not lead to a reconsideration of the economic policies that had already been implemented on the basis of the original advice (Cassidy, 2013; see also Saltelli et al., 2013 and Saltelli & Funtowicz, 2014).

Another known critique is the abuse of cost benefit analyses and risk assessment offered as scientific advice to govern a myriad of matters from environmental to health, educational and financial matters. Indeed, this is a field on its own right, e.g. Krimsky and Golding (1992); Perrow (1984); Funtowicz & Ravetz (1990); Jasanoff (2010); Taleb (2007; 2012); Saltelli & Giampietro (2016) and European Commission (2007). Suffice say here that there are cases where cost benefit analyses are misused, quantifying the unquantifiable, or

where a problem of acceptability of a new technology is arbitrarily reframed as an issue of risk (see e.g. Winner, 1989). A deeper discussion of the issues dealt with in this section can be found in Benessia et al. (2016); a discussion of the root causes of science's crisis and its possible solutions is in Saltelli et al., 2016).

2.2. Quality in times of distributed knowledge production

Ulrich Beck (1992) called "reflexive modernity" a state in which growing bodies of knowledge are accessible to growing number of individuals with added agency that enables them to intervene in the world. Several authors have anticipated this state of deeper involvement of non-experts in scientific dimensions of societal matters. Funtowicz and Ravetz (1990) called for reflexivity through their concepts of "extended peer communities" and "extended facts" which is at the core of post-normal science; Callon et al. (2001) describe it as "public dialogue and participation model", whilst Jasanoff (2005) explores this state affairs through the concept of "civic epistemologies". These concepts explicitly reject the deficit model (inspirational for the Public Understanding of Science (PUS) movement) and the thesis of the public's inability to act on scientific issues, supporting instead efforts for democratising science.

Indeed, in Europe, the UK BSE "scandal" of the mid-1980s to mid-1990s is often cited as pivotal in the change of direction in the relations between science and policy making. This crisis was perhaps instrumental in calling into question the deficit model, i.e. the idea that opposition to "innovation", in particular techno-science is due to the publics' and policy makers' scarce knowledge of science. Unfortunately, this model is still alive, even if increasingly challenged. During the 1990s a new language of "science & society" towards dialogue and engagement emerged. From a historical perspective, one can say that a key moment was the publication of the 2000 House of Lords report on Science and Society followed a year later by the European Commission's Science and Society Action Plan (European Commission, 2002), or the UK government sponsored debate on genetically modified crops "The GM Nation?" often seen as an example of response in the aftermath of the BSE crisis (Gaskell et al. 2003). It is instructive to see how the EC research programmes addressing publics' interfaces have been changing their name: 'Science ***and*** Society', 'Science ***in*** Society', 'Science ***with*** Society', and with Horizon 2020 'Science ***in and with*** Society'. In the EU parlance, public engagement and ethics are at the heart of the "responsible research and innovation" (RRI) initiative from 2013 onwards.

It is also in the early 1990s that several cures (perhaps an inevitable trend) based on a greater role for societal scrutiny were proposed, such as PNS due to Funtowicz and Ravetz (1991; 1992; 1993), Mode 2 Science due to Gibbons *et al.* (1994) and others – see

Carrozza (2015) for a recent discussion of these frameworks. Q*uality assurance* is the core argument of post-normal science and also of our suggestion for identity change of institutions like the JRC. In a workshop on post-normal science held at the JRC in March 2016, the consideration was made that:

> "*The attribute Quality is, at once, pragmatic, recursive and moral. It is pragmatic in that 'fitness for function' depends on that function and on whose purposes are served by it; hence Quality is tightly embedded in a context of users and testers. It is recursive, for as the Roman poet Juvenal wrote in his Satires, 'Quis custodiet custodes ipsos?' - who guards the guardians? And it is moral, since no externally enforced system can sustain itself; 'wherever there's a system there's racket to beat it'. The maintenance of a system of quality assurance is thus a constant struggle against its inherent self-corrupting tendencies."* Jerome Ravetz, @ New Currents in Science: Challenges of Quality 3-4 March 2016, JRC.

As Ravetz points out, there is no simple way to define and measure 'Quality'. Especially in the case of policy relevant science, the criteria of quality, and the measures for quality assurance, must reflect the extended constituencies of those who will be affected by the policies implemented. Hence, it is hard to think of simply measuring it; quality cannot be thought to be the activity of a specific elite, but rather needs to be performed collectively in continuous collaborative ways.

Quality becomes ever more important in the Do It Yourself (DIY) era. The digital culture and phenomena like Citizen Science (Irwin, 1995 and Wildschut, this issue), DIY science (Nascimento et al., 2014; Ravetz *et al.*, 2015) and the "Open Everything" paradigm (Steele, 2014), with a broader community of actors that produce, preserve and deploy knowledge, certainly has effects on mainstream scientific institutions' knowledge production, assessment, organisation and governance. Such deeper involvements of society in the scientific enterprise arise from individuals and communities with different agency, gazes and guises, relying on voluntary and self- or community supported initiatives. Makerspaces and hackerspaces, for example, are emblematic movements of this trend, but the recent past has also witnessed crowd-funded radioactivity measurements in the aftermath of Fukushima (McNeill, 2014), the Quantified Self movement that deals with health *self-veillance* and a general drive toward commons-based "peer production" of knowledge (Benkler & Nissembaun, 2006). The discussion above interests these arrangements and practices not least because these movements challenge mainstream scientific epistemologies, qualities and ethos (Kønig et al., this issue) and the use of scientific 'facts' for policy making.

One could thus argue that the current digital culture is de facto implementing the concept of "extended peer review" and extended quality assurance described in PNS, by engaging different types of knowledge and involving an extended community of social actors. This extension of participation calls for a reflection about the nature of the knowledge produced, and on the criteria and processes for assuring quality and integrity.

3. Post-normal science as reflexivity practice: a new identity for boundary institutions?

3.1 Why we need a new identity

As described in the last section, science experiences a crisis of quality, trust and legitimacy affecting both its practice and its ethos. The expectation that science sets the "facts" that underpin policy making is well encroached in the political discourse. Likewise it is assumed that political decisions can be settled by science under the "evidence based" flag in European policy discourses, see Braun & Kroop, 2014. The former Chief Science Adviser of the EC made a quest for a centralised "evidence service", suggesting then that "*the incoming Commission must find better ways of separating evidence-gathering processes from the 'political imperative'*" (see Wilsdon, 2014). This episode is worth mentioning because this suggestion resonates well with the Demarcation Model discussed by Funtowicz (2006); this aspiration is problematic because on the one hand it rejects the idea that co-production of scientific and social order (Shapin & Schaffer,1985; Jasanoff 1996); on the other hand, it does not recognise that evidence gathering is also a matter of choice of the questions to be asked and researched; of the framings in which questions are tackled; of the governance of uncertainty and the unknowns; of the choice of the spoke persons and communication strategies. The idea that science is apolitical or value-free is being repeatedly contrasted (see Saltelli & Giampietro, in this issue). As discussed earlier, the framing of the question to be addressed, as well as the method chosen to tackle it, depend on the actors involved. In some cases the danger is that of *evidence-based policy* being turned into *policy-based evidence*, not necessarily because of specific pressures but simply because of the frantic pace of the policy processes, whereby by the time the bell for evidence rings in the office of the tasked officer the policy options have already been taken. It is in these settings that quality assurance must rely both on higher standards of institutional peer review process as well as on engagement with relevant societal actors. Hence, the epistemological and practical problems need to be solved jointly, based on the recognition that they are co-produced.

Instrumental or disingenuous goals dominate thinking about evidence-based policy (see e.g. Boswell 2009 and Saltelli & Giampietro, 2016, for a review). Yet, as Boswell (2009) argues often the impact of scientific advice on policy making is rather symbolic, serving both as credibility device and as opportune grounding for policy makers' objectives. These aims are certainly important, but here we would like to offer scientific advice as an opportunity of societal reflexivity. Reflexive practice in institutions like the EC is not only about the chosen body of knowledge to sustain particular claims, the legitimation or de-legitimation of relevant voices but also and above all, the critical and comprehensive verification of existing narratives against a broader spectrum of worldviews.

It is in this context that we argue that the foundations of post-normal science are most relevant if we are serious about taking the challenges of our times in institutions like the JRC. Time and spaces need to be actively created where all bodies of knowledge are mobilised into discussions before the relevant knowledge - either requested from or offered to policy circles- is produced and circulated. But what changes are needed in institutions like this to accommodate such needed spaces and time?

Elsewhere (Guimarães Pereira & Saltelli 2014) we have examined science advice models and their potential relevance for a boundary institution such as the JRC. In this paper we will not engage in this discussion but we argue that scientific advice to policy deals with similar types of tensions that impinge the governance and practice of science that we described earlier. Therefore, we note that the practices and commitments to knowledge quality assurance that are performed in boundary institutions cannot be extrinsic to the practices and commitments of the institutions where that knowledge is used.

3.2 PNS Practices and Commitments

Boundary institutions like the JRC should explore a different understanding of knowledge production and flowing in order to respond to the on-going crises. The JRC, in particular, is in a unique position to create a new identity organised around reflexivity and quality assurance practices. Two unique features facilitate this endeavour: it being part of the policy cycle, on the one hand, and its natural closeness to scientific production on the other.

Such a new identity emphasises a commitment to three intertwined and complementary cultures, which embrace the post-normal science framework: that of quality assurance by an extended peer community: that of reflexivity and critical thinking; and finally that of an ethos of care.

Quality Assurance by an extended peer community: as discussed earlier, there is no simple way to define and measure 'Quality'. Several decades of STS and PNS research have highlighted that the kind of quality assurance we suggest here can only be done by integrating an extended peer community, which in turn requires *extended peer review practices that* acknowledge emerging epistemologies, putting critical thinking at the heart of the institution's operation. The aim is to deliver not only scientifically valid, but also socially and ethically robust scientific advice to policy making, grounded on PNS and science and technology studies, acknowledging that a broad spectrum of norms needs to be consulted. The tools to assure quality of policy relevant science may come from within science itself as there are branches of science that have been engaging in these sorts of scrutiny for decades, but also from the humanities and the arts, as well as from the continued engagement of the relevant extended peer communities. These different forms of engagement value dialogic governance. They acknowledge that when facing different uncertainties and unknowns, the anticipation of impacts, the decision about which facts and norms are relevant, the questions to be asked and the methods of enquiry are all collective tasks, not to be surrendered to powerful elites, not even to an elite of scientists.

Reflexivity and Critical Thinking: our proposal includes securing time and space for researchers to act sceptically and inquisitively about policy agendas and political imaginaries which use scientific information as a relevant body of knowledge, in other words the "evidence" in the "policy based evidence". Such space is about nurturing an in-house culture of critical and reflexive thinking about techno-scientific issues and their societal implications. This is achieved by conducting collaborative case studies, exploring synergies across teams co-working on files in need of this type of approaches. This reflexivity model of scientific production and circulation aims at challenging long standing narratives and at testing their relevance against societal agendas and societal values. At the JRC, our case study, there has been some signals of change, it being in the form of workshops that openly challenge current narratives (Guimarães Pereira et al., 2015), look into how current problems of the scientific endeavour are challenging our received meanings of quality (Ravetz et al. 2015; Saltelli et al. 2015; Guimarães Pereira & Ravetz 2016); other types of signs rise from current projects that bring humanities and arts as genuine bodies of knowledge into policy discussions, as well as heterogeneous societal engagements.

Ethos of care: De La Bellacasa (2011) argued for an ethos of care in the study of science and technology, introducing the notion of 'matters of care' as a way to generate 'caring relationships' which allow investigation of not only what ethos is behind techno-scientific

innovations but also asking 'how to care'. The work of De La Bellacasa is relevant for our argument, as we need to ask the same questions when we frame a policy issue, choose the relevant bodies of knowledge to address it, and implement and monitor action.

For the JRC, this move is plausible, as it has been one of the loci of the PNS scholarship and practice, see e.g. Funtowicz and Ravetz, 1990; 1991; 1992; 1993; Guimarães Pereira & O'Connor, 1999; Gough et al., 2003; Guimarães Pereira & Funtowicz, 2013.

4 Final remark

In our previous brief (Guimarães Pereira & Saltelli, 2014) we suggested that the main challenge faced by an organisation such as the JRC in this process is that important actors of change - the scientists themselves and their institutional counterparts, are at the same time engaged and committed with those existing styles and methods which would be most in need of change. The elements that we presented here calls for changing ways of working and for a broader realisation that we have reached a point of non-return. Hence we suggest that 'boundary organisations', such as the JRC taken here as an example - should appeal to three cultures, i.e. (i) of quality assurance involving the relevant extended peer community, (ii) of reflexivity and critical thinking and (iii) of ethos of care. There is no easy way out to counteract what is described as democratic deficit affecting institutions like the EC; however, we argue here that by choosing to work within existing constraints while embracing reflexive and dialogic notions and practices is a first step for an identity responsive to contemporary challenges. These notions and practices are at the heart of the post-normal science framework, requesting consideration for the emerging ways in which science is being produced, quality assured and circulated in institutions that support or advise policy making. This means, in practice, a serious commitment to engage different ways of knowing to deal with societal challenges while fostering an identity close to narratives of care about humans and non-humans. We contend that this is not the request of a few but rather a political one.

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ERASED FOR REVIEW.

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Box 1.1: Changing mission of the JRC over the last decade (authors' emphasis).

2002: The mission of the JRC is to provide **customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies**. As a service of the European Commission, the JRC functions **as a reference centre** of science and technology for the Union. Close to the policy making process, **it serves the common interest of Member States**, while being **independent of social interests whether private or national**.	**2013:** As the Commission's in-house science service, the Joint Research Centre's mission is to provide **EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle. Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges** while stimulating **innovation** through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.