

# Science, technology and policy as a critical nexus

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## Abstract

Science, technology and policy form today a nexus, crossed by rapid transformations and conflicts, which permeate all discussions about the human condition and future. Existing attempts to capture separate elements of an ongoing crisis in these three spheres miss their structural coupling, and hence fail to imagine a plausible way out. The crisis has elements of inevitability linked to our addiction to technology and communication. Science is - in this reading, a sore problematic core. Science's epistemic authority is today staked on a series of claims – including on climate change, which the present analysis sees as divisive. A spiritual Reformation of our relation with science is suggested as a point of attack to deal with the nexus. This is in line with a long intellectual tradition of critique of our relation with science and technology.

*“I am, like most other critics, armed less with solutions than with problems”*  
Neil Postman [1].

## 1. Introduction

### The nexus

The concept of a critical interface between science, technology and policy was formulated by Giandomenico Majone in 1989 [2]. The present work posits that the interface has become a volume, eating up into the surrounding space, up to filling it up completely. All that takes place today and is significant to our human condition has to do simultaneously with science, technology and policy. Important transformations are shaking our collective life, whose core might be identified as a science-technology-policy nexus. Science – whose so called reproducibility crisis is only a small piece of the puzzle [3] - is at the core of these trajectories which can be seen as a threat to our organized life [4], [5]. In this reading, science's crisis cannot be separated from the crisis of trust in expertise, from our apparent inability to control technology, and from the insurgence of anti-system convulsions within mature democracies.

### Was the crisis inevitable?

What makes the present crisis of the science-policy-technology nexus unprecedented is its apparent inevitability. A few years ago, a technical magazine devoted its cover to the image of a baby boomer protesting; “You promised me Mars colonies; I got instead Facebook” [6]. At a superficial reading, one might image that the present trajectory is just an accident of

technology; in a parallel universe, perhaps, the human race is already on Mars without Facebook. What if this trajectory was ineluctable? For the fathers of the ecological movement humans are compulsive technology adopters, and this is already a good indication of our fate, since we can more easily adopt a system like Facebook than we can adopt a piece of the space program. But what if we are - by result of our evolution, compulsive adopters of more and better strategies, forms and media of communication? For those familiar with the social systems theory of the German sociologist Niklas Luhmann this is precisely what humans share. Our culture has developed successively more sophisticated generalized symbolic media of communication – money, power, even love as passion [7][8]. If we accept, additionally, Yuval Harari's thesis that humans are chimpanzees whose cooperation is ensured by belief in shared stories [9], then we can interpret the role of social media as making these shared stories fragmented and divided. Finally, this ineluctable trajectory can also be seen in the context of the synergetic coupling of technology with capital noted by Lewis Mumford in the thirties [10].

### Old or new?

One of the consequences of our increased mediatisation is the so-called post-truth era – an unfortunate expression as it assumes a 'truth-era' which went possibly missing. It is easy to say that this is an old story in a new format, but is this the case? For example, the Twitter hashtag #jewsdid911 is practiced by a community attributing the 9/11 terroristic attack to a Jewish conspiracy. One could say that there is nothing new here, offering as a precedent the forgery of the Protocols of the Wise Men of Zion, or the many theories used to justify pogroms. The difference is that the present technology makes the hashtag universal - it can be read in every part of the planet, is instantly updatable with new content, and – if desired – automated, to the extent that automatic algorithms can be – and actually are, generated to engage humans around the subject, as to stoke hatred and division [5]. The reader may decide if this is just a new format or rather a new world.

### Chains of transmission?

The chains of transmission between science and technology on the one hand and policy and society on the other have multiplied; mathematical models, artificial intelligence, nano and bio technologies impact everyday life and behaviours via channels such as algorithms for the social media and the financial system, possibility of human enhancements, genetically modified food, pesticides, new weapon and control systems, and many others. Beside permeating our collective lives, science is a source of legitimacy for the modern state, and together with technology an engine of growth, generally equated with progress. When neither science nor experts are trusted, important transformations can be expected in all aspects of collective life. That is why a good understanding of science's crisis is an important starting point to understand the present.

Jerome R. Ravetz has produced early diagnoses of many of the oncoming transformations [11], identified fault lines in our science-based globalised civilizations [12] and interpreted change as the result of the maturing of structural contradictions [13]. As per science's own crisis of quality control Ravetz has offered an original reading in terms of the social nature of the scientific activity, whereby the quality control arrangements in place when science was little become inadequate when science is big, or mega [11][13]. The inadequacy manifests itself in a mismatch between ideals and incentives in research practices, the impossibility to catch up with bad science, and a systematic misdiagnosis of the present science's crisis [11][14].

These insights are extended here to illustrate the most relevant points of tension affecting the nexus. The focus shall be on areas of contradiction or conflict, their symptoms, and their implications, offering a view of how these could be addressed. It will be argued that this reading is in contrast with reductionist, denialist, or opportunistic views of the present science's crisis.

## 2. Science's public image and science's roles

### Science for democracy?

There has always be an ideological divide, even in academia, between an Enlightenment based progressive and emancipatory image of science against that of science at the service of imperialism, colonial powers and exploitation [15]. Today, the use of Facebook's algorithms to tweak election in the US, to encourage genocide in Myanmar, or to permit to 'patriotic trolls' to scare opponents in receding democracies [16] all but kills the narrative of science supporting democracy – if we accept that Facebook's technologies originate from science. A science which distracts and conspires runs counter to the dreams of the American pragmatists of science as tool for social progress and for the discovery of problems to be brought to the attention of the public [17]. Also gone is the image, expedient during the cold war, of a science as a self-regulated republic[18], of science as a democracy, operating in a market of its own, and hence superior to communist science [19]. As per science self-governing and self-correcting nature the present offer little consolation. Gene manipulation on humans [20], on smallpox viruses [21] and on military and control technologies shows how this vision can be illusory. If nothing else, the increasing proletarianization of the research labour force [22], predicted by the sociologists of research [23], shows a science which reproduces the sins of the society, rather than being a cure for those. Another conspicuous element of mismatch between science's image and role is that science and innovation are presented as a solution for generating growth and jobs, even when serious concern exists about the distribution of growth and the very existence, and nature, of these jobs [24].

### Climatic blues

There are several ways through which the official image of science rings as simultaneously hollow and instrumental, but nowhere as clearly as in the field of climate change. Here science, if we are allowed to personalize it for the sake of illustration, purports to be a victim of big oil in relation to climate change. According to this narrative science attempts to save us and the planet, and if our lifestyles have not changed yet it is because of the so-called deniers, helped by the well documented [25] fossil fuel industry strategy to make energy and climate as an intellectual battleground of conservatives, especially in the US. This reading is perhaps disingenuous – we could change our consumption pattern ourselves irrespective of what deniers and president Trump choose to do.

The success of the narrative evident: there is no public figure which is not convinced that climate poses the most urgent threat to mankind, and the patent institutional failures to address the climate threat – e.g. via the Paris agreement - are presented as a symptom of the deterioration of our global political systems. Paul Krugman deplores the depravity of climate deniers [26], while Vandana Shiva, Naomi Klein, Noam Chomsky and other intellectuals sign an open letter calling for citizens to rise up and organise for the climate 'emergency'. The democratic party in the US proposes a Green New Deal [27], whereby Joseph Stiglitz assures with a confidence only economists can muster that "It is better to leave a legacy of financial

debts, which our children can somehow manage, than to hand down a possibly unmanageable environmental disaster" [28].

Leaving future generations – but its own offspring, one be forgiven for suspecting – to the wonders of the gig economy is hence the solution. Ironically, the only institution proffering the heresy that jobs come before climate is the catholic church [29].

In order to keep the attention of the citizenry focused on the climate battle, a ‘can do’ attitude is being held, offering simplistic images of an economy which can be made circular, or rapidly decarbonized, against historical evidence of past transformations [30]. Mathematical models are shown as capable of predicting the damage in dollars from hurricanes and draughts up to the year 2050 or 2100 [31], [32]. Problematic quantifications play a key role in these narratives [33][31]. Thus, an educated public has been led to believe that in order to limit temperature increase to 2 degree centigrade with a 50% certainty a greenhouse-gas concentration of 450 ppm CO<sub>2</sub>-equivalent should not be exceeded. Needless to say, these crisp numbers are model-generated [34], and convey a spurious impression of accuracy and control.

By successfully staking all its epistemic authority on climate, science has acquired a virtuous image at the cost of detracting attention away from other pressing environmental concerns, from the collapse of fisheries to the dramatic decline in insects due to pesticides [35] - not to mention a long list including atmospheric pollution, persistent organic pollutants, endocrine disruptors, and so on. Worse still when climate is invoked to exculpate pesticides for a declining insect population [36] or to exculpate global imbalances as a major cause for migration and conflict [37]. Those scientists who believe that climate is not even the most urgent environmental threat - let alone an economic and geopolitical one, have to evaluate carefully what to say and where. One of the best known sociologists of science declares his allegiance to the climatic cause and expresses concern about the misuse of his earlier work from deniers [38]. The resemblance of these practices to those of official religion is discomfiting.

For the record, the author agrees that humanity is conducting a large-scale geophysical experiment with the planet [39], while he disagrees that the end is nigh and that phasing out fossil fuels in a few decades is achievable [40]. The ‘uncertainty monster’ [41] about what to do would suggest scope for a civilized dialogue between the “act now!” [42] campus and the “wait and see!” one [43].

At the time of writing the present work, French citizens protest against a green tax on fuel. To use a form of taxation which hits the poor more than the rich to fix the environment appears to many protesters as the ultimate effrontery of the elites.

Science is thus contributing to a hiatus which is likely to alienate from science a majority. This is regrettable, as science is our most valuable tool, and leaving it as the preserve of the elites, as predicted by the so-called techno-spit scenario [44], is dystopian. In this scenario one would be left with an affluent super-technological and possibly trans-human/immortal minority [9], and a useless majority left glued to its mobile phones and tablets [45].

## A distraction without strategy

The image of science enrolled to defend the planet downplays science's role in the construction of the present 'Brave New World' of inequalities and deteriorated democratic representation. In the eponymous novel of Aldous Huxley citizens are kept happy and sedated with a recreational drug. Our social media dominated world – with Facebook, Twitter and Instagram as our drugs - resembles this scenario more than the dictatorial prospect of George Orwell '1984', where a Big Brother uses propaganda to achieve control of the minds.

At a moment where technology pushes hard against the mind-machine barriers and philosophers reflect on what will happen when we shall have internet as an implant in our brain [46], the prospects of such a brave new world should be taken seriously.

Science in the guise of big data, artificial intelligence and algorithms has become a tool for the hacking of minds [4] and of elections [5], with more to come thanks to technologies such as deepfake - which allows producing fake proofs of people doing and saying things they never did or said. Bots can be used to stoke anger and division, on issues ranging from firearms to vaccines, while deep learning technologies applied to social media make us worse persons only in order to keep us longer connected, i.e. even without the explicit objective of making us less human and more divided [5]. In the present world, on top of the old strategy of distraction, technology adds distraction, and confusion, without a strategy.

While the process of reduced trust in all forms of expertise – including the expertise of the political establishment – can be said to be a long and at times recurring process [47], the acceleration brought about by technology is a game changer. Note that even 'classic' causes of decreased trust, such as e.g. instances of corruption of the political, mediatic, and economic spheres, receive immediate amplification ('go viral') thanks to the new media [48], whose algorithms detect the attractive potential of these news to keep consumers connected.

Add to this our total dependence from expertise and experts. For the already mentioned Luhmann all our knowing – including expert knowledge - is second order knowing, each expert relying on a chain of other experts. For Elijah Millgram this renders the experts methodological aliens to one another, and our age the age of the great endarkenment [49]. Our increased dependence upon untrusted experts generate resentment and further loss of trust in a vicious circle, which adds to the present nexus.

## Minority report

The reading offered so far is evidently a minority report. Scientific institutions may be seen in denial of the existing crisis [50], while a large part of the intelligentsia indulges in an acritical celebration of enlightenment science [51], and eulogizes the sheer power of facts to inform evidence based policy [52]. A worrying symptom of the self-destructive tendency of science is the resurgent risk of science wars between natural and social sciences, as seen in the recent hoax targeting the so-called grievance studies [53]. For the reader unfamiliar with these unfortunate practices, the hoax consists of producing one or more meaningless studies and having them accepted by a journal in the targeted field, a practice started about two decades ago. A more recent science war has erupted in the US, where conservatives target science-based regulation riding the reproducibility crisis [50], weaponizing it as they did in the past with transparency [54][55]. The true losers in these wars are those – perhaps soon to become

a majority – who succumb to all sort of conspiracy theories and fatalism. The same replication crisis may be expected to have corrosive effects on public trust in science [56].

### Wonders of science

Science – both natural and social – has not lost its capacity of delivering wonders. In the social sciences, Anthony Atkinson, Emmanuel Saez and Thomas Piketty have succeeded in putting inequality on the agenda, in line with the social discovery function of science. Physics – though accused of stagnation, gives us the confirmation of the existence of gravitational waves. Artificial intelligence – in spite of the dystopian uses to which it can be put, seems set on an acceleration path with both enthuses and scares. At the same time the so called ‘invisible science’ [57] delivers comforts which we take for granted, and even the attributes that make AI dangerous for democracy, i.e. universality, updatability and automatability, can be useful. Applied e.g. to medicine, a new vaccine can in principle be communicated, manufactured and distributed at unprecedented speed. It must be understood that calling attention to science’s problems and their implications aims to save science, not to dispose of it.

### 3. Reformation?

A solution to the contradictions just outlined implies a collective recasting of our conversation about science. This is supported by a long intellectual tradition of critique of the role of science and technology, which has highlighted the contradiction between the power of the instrument and our incomplete capacity to master it [58]. The critique – which sees the contradiction in both our consciousness and in society, has been voiced by anarchists, by fathers of the ecological movements, by philosophers of various schools and intellectual traditions, by intellectuals active during the protests for the Vietnam War in the sixties, and by scholars of history and philosophy of science. Diverse voices have called for a reconsideration of our ‘master narrative’ of science as emancipation and foundation of the modern state [59], where trust in scientific knowledge and trust in the prevailing social order are linked [60]. Alternatives are sought to the key metaphors of modernity as ‘man as master and possessor of nature’ and ‘nature as a machine’ – both made possible by science [44].

The idea of a Reformation of science, to make just an example among the many we cannot report here, was voiced by Paul Goodman in 1970 [61]:

*Science, which should have been the wind of truth to clear the air, has polluted the air, helped to brainwash, and provided weapons for war.*

The theme of a Reformation for science, analogous to the one shaking the church with Luther, and made possible by the internet as the new press, is a recurrent one in present analyses [62], while the concern for military or authoritarian applications of science sees a resurgence associated to the convergence of nano, bio and IT [63] technologies.

A spiritual reformation of science would act simultaneously on all elements of the nexus. Quoting again from Paul Goodman:

*By "Reformation" I mean simply an upheaval of belief that is of religious depth, but that does not involve destroying the common faith, but to purge and reform it. (Of course, such a religious reform may be politically revolutionary.)*

*It is evident that, at present, we are not going to give up the mass faith in scientific technology that is the religion of modern times; and yet we cannot continue with it, as it has been perverted.*

... But how?

After the radical pronouncements of the seventies the pendulum swung in a different direction with neoliberalism, and the discipline of economics – neoclassical and mathematized - becoming even more firmly at the helm of evidence-based policy. This brought about a return to the simplifications and linearization of the after-war era. Decisionism [2] – loosely speaking, the idea that all policies can be evaluated with a good cost benefit analysis , was back. The pendulum brought an enhanced role for the market in science and technology matter, with the so called commoditization of research [64], and fresh breeds of techno-optimism [65]. Increased inequality brought with it increased scope for lobbying [66] and for influencing minds and elections; this process is energized by technology [67].

The pendulum hasn't stopped yet, on the contrary it seems that part of the present zeitgeist is to abandon doubt. This befits an ancien régime which excludes from the real all dissonating voices. By way example, one can see how clever technologists such as Erik Brynjolfsson and Andrew McAfee, while pointing to the danger of the present machine revolution in a popular book [24], eventually lose their reservations, and go on to encourage entrepreneurs to embrace platform capitalism as a matter of survival [68].

If a Reformation didn't work out in the seventies, why should it work now? And foremost, how? Who shall be its Luther? As per Tetzl, the indulgency selling friar provoking the spark of Luther's indignation, there are many candidates, so many to instigate boredom rather than indignation. Should one identify a different Luther for each instance of a Tetzl? So for the bad scientists serving unscrupulously power, we could have a brave antagonist defending citizens in need [69]. For those who violates ethical or anti-proliferation norms, the upholders of the same norms. For each shoddy quantifier we should have the concerned methodologist to keep the discipline clean [70].

It is clear from the choice of citations of the present work that an important element of the solution would be to rediscover the thought of the anarchists, philosophers, protesters, ecologists who have advanced doubts on how the 'machine' should be handled. Also old movements such as British Society for Social Responsibility in Science (BSSRS), or the American group Science for the People [71] would need more recollection. Along the same lines a teaching of science which includes 'housewife epidemiology', would benefit all exposed to it. So high school students could usefully read – beside Orwell's '1984', a book such as, for example, 'Love Canal' by Lois Gibbs [72]. Love Canal was a nasty case of environmental contamination minimized by regulators and authorities – analogous to the case of Flint, Michigan today [69]. The case resulted in premature deaths and stillborn babies. Reading about Love Canal and Flint, students would learn that dystopias are not necessary in the future, and that - while holding science in respect, new forms of civic vigilance on science and technology are needed.

Closer to our times, post normal science (PNS) constitutes perhaps the most mature intellectual critique of possible abuse and misuse of scientific work. The name post-normal may appear to some readers as associated with post-modernism and its purported sins of

constructivism and relativism. Post normal science (PNS) is instead a system on empirical and practical insights for the use of science at the science, policy, and technology interfaces. PNS scholars have been prophetic in their vision of the oncoming transformations of and from science and technology [3], and on the need to put quality and a proper appreciation of the uncertainties of the core of scientific practice [73]. PNS foundational article [74] is the most cited paper in the literature of future studies involving foresight, forecasting and anticipation [75].

Many are now familiar with the mantra of PNS "facts uncertain, values in dispute, stakes high and decisions urgent", and with its iconic uncertainty-stakes diagram. The once radical message of PNS, neither value-free nor ethically neutral [76] – with its concepts of critical science, prudent technology, and the need for extended peer communities, appears now particularly suited to make sense of rapid transformations taking place at the science-policy-technology nexus. The message of PNS – possibly a movement of ‘informed critical resistance, reform and the making of futures’ [77], holds it that in order to change the world one needs to change science first. But how?

A to-do list most aimed at scientists themselves – could include [50] a humbler approach to what science can and cannot deliver, also achieved by letting go of an idealized vision of Enlightenment, a reframing, or perhaps a resizing, of the call for global mobilization on climate in the context of a host of environmental threats of different levels of urgency, a refraining from self-destructive science wars, the enhancing of communication between scientific communities, a rebalancing of power asymmetries in the use of evidence - by taking side with the weakest party in social and environmental controversies, and a contrast to the collapse of trust in science achieved with work of good quality – *sensu* PNS.

Each discipline should conjugate the list within its problem area. As an example, in the field of statistics a manifesto for action could include inter alia fighting ‘cargo cult’ – read shoddy - methodologies and using the tools of statistics to defend the integrity of the electoral process [70]. Each discipline should pursue humility by engaging – and teaching, its own history. This is evidently an agenda for resistance, as a solution to the problems describe here belongs to a different world which is not here yet. It describes an attitude more than a process. Neil Postman, somewhat romantically, associates the idea of resistance to a fighter who “maintains an epistemological and psychic distance from any technology, so that it always appears somewhat strange, never inevitable, never neutral” [1].

An awareness of the non-neutrality of scientific methods themselves is part of the author’s own recipe to improve quality in the use of statistics [70] and of mathematical models [78][52]. A new ethic of quantification [79] is needed in the context of the nascent field of sociology of quantification [80].

#### 4. Conclusion

The present crisis affects all three ingredients of the nexus science, technology and policy, and trying to address this crisis one bit at the time, from open science to cure the reproducibility crisis to algorithmic governance to rein in the weapons of math destruction [81], risks ignoring the tight structural coupling between those systems. The ingredients of a solution offered in the present work can be seen as belonging to a Reformation of science in



its relation with both our individual spirituality – reconsidering the use of science as an ersatz religion, and with society, negotiating a different pact between science and society, a change of moral allegiance analogous to that operated by Reformation. This is to be intended as a long process; most likely than not, the present crisis will become worse before it can become better [82].

Science has a fundamental role to play in this movement of resistance, starting from its own house, not only in relation to the reproducibility crisis, but for the good of its own internal morale. Continuing on the present trajectory, one can easily imagine a science where artificial intelligence and the convergence of nano and bio technologies substantiate the fears of *Black Mirror*, a popular television series on the dystopian evolution of technology. The abuse of military [83] or gene [20] technology are with us already. Such a science would remain divided among quarrelling factions, defending corporate or corporative interests [84], incapable of modifying the existing system of perverse incentive [85], or unable to develop remedies which will not backfire [86]. Open science initiatives could thus fall prey to platform capitalism [87], while science’s labour force could end up divided into a well-connected elite with grants and tenure and a non-elite of for ever precarious researchers [77]. Such a scenario within science would parallel and reinforce society’s ‘techno-split’ [44] between an elite, whose members trust science and can recruit its services, and a majority estranged from ‘mainstream’ or ‘official’ science, pray to all sorts of conspiracy theory and seeking retribution with purported anti-system parties and candidates.

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