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Towards a New Ethos of Science or a Reform of the Institution of Science?

Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness

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The international journal *NOvation: Critical Studies of Innovation* was launched to contribute to the rethinking and debunking of innovation narratives in STS (Science, Technology and Society) and STI (Science, Technology, and Innovation). There is a need to critically examine studies of innovation and obtain a clearer portrait of innovation than the depiction this field has been accustomed to. The journal questions the current narratives of innovation and offers a forum for discussion of some different interpretations of innovation, not only its virtues, but also its implications. In this sense, NO refers to non-innovative behaviors, which are as important to our societies as innovation is. Failures, imitation and negative effects of innovation, to take just some examples of non-innovation or *NOvation*, are scarcely considered and rarely form part of theories of innovation.

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Towards a New Ethos of Science or a Reform of the Institution of Science?

Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness

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ABSTRACT

Keywords: open science; Robert K. Merton; Covid 19, research values; scientific integrity; research assessment.

In this article, I will explore how the underlying research values of 'openness' and 'mutual responsiveness', which are central to open science practices, can be integrated into a new ethos of science. Firstly, I will revisit Robert Merton's early contribution to this issue, examining whether the ethos of science should be understood as a set of norms for scientists to practice 'good' science or as a set of research values as a functional requirement of the scientific system to produce knowledge, irrespective of individual adherence to these norms. Secondly, I will analyse the recent codification of scientific practice in terms of 'scientific integrity', a framework that Merton did not pursue. Based on this analysis, and illustrated on the case of COVID-19 as a case in which the institution of science was challenged to deliver urgently on societal desirable outcomes, I will argue that promoting open science and its core norms of collaboration and openness requires broader governance of the institution of science in its relationship with society at large, rather than relying solely on self-governance within the scientific community through a new ethos of science. This conclusion has implications for re-evaluating research assessments, suggesting that the evaluation of the scientific system should take precedence over evaluating individual researchers, and that incentives should be provided to encourage specific research behaviour rather than solely focusing on individual research outputs.

INTRODUCTION

Over the past decade, we have witnessed a gradual and consistent evolution of research practices towards a more open science (Miedema, 2021). This shift has been driven by both internal expectations within the scientific community and external demands from research policies. The European Commission (2014 and 2015) and the National Academies of Science (2018) started to foster open science in research policy with the expectation that open science will:

- Enhance credibility by addressing issues of scientific integrity in an open and transparent context.
- Improve reliability through early and effective data verification made possible by open science.
- Increase efficiency by preventing redundant research efforts and fostering broader collaboration.
- Meet societal demands by making science more transparent and accessible.

The push for open science within the scientific community has been further reinforced by negative trends such as slow publication processes, criticism of the peer review system, and challenges in reproducing research results (*Nature*, editorial May 2016). Moreover, the urgent need for open science outside the scientific community has been highlighted by the COVID-19 crisis, which exposed the inefficiency of the scientific system in responding timely to public concerns. Against this back-drop, I defined 'open science[1]' as the early sharing of knowledge and data in open collaboration with relevant stakeholders (von Schomberg, 2019; Burgelman *et al.*, 2019). Transitioning towards open science is essential for enabling responsible research and innovation (von Schomberg *et al.*, 2023; Owen *et al.*, 2021).

In this article, I will explore how the underlying research values of 'openness' and 'mutual responsiveness', which are central to open science practices, can be integrated into a new ethos of science. The key question to address is whe-

[1] I prefer to talk about 'open research and scholarship' which explicitly clarifies the inclusion of the social sciences and humanities. However, in policy circles the term open science is now consistently employed.

ther practicing open science necessitates a transformation of research cultures. Firstly, I will revisit Robert Merton's early contribution to this issue, examining whether the ethos of science should be understood as a set of normative guidelines for scientists to practice 'good' science or as a functional requirement of the scientific system, irrespective of individual adherence to these norms. Secondly, I will analyse the recent codification of scientific practice in terms of 'scientific integrity', a framework that Merton did not pursue. Based on this analysis, I will argue that promoting open science and its core norms of collaboration and openness requires broader governance of the institution of science in its relationship with society at large, rather than relying solely on self-governance within the scientific community through a new ethos of science. This conclusion has implications for revaluating research assessments, suggesting that the evaluation of the scientific system should take precedence over evaluating individual researchers, and that incentives should be provided to encourage specific research behaviours rather than solely focusing on individual research outputs.

MERTON REVISITED

In 1942, Robert K. Merton, one of the founders of the sociology of science, authored a short essay titled 'The Normative Structure of Science', which included a section called 'The Ethos of Science'. Merton described the ethos of science as 'that affectively toned complex of values and norms which is held to be binding on the man of science' (Merton, 1942). He introduced the CUDOS norms, consisting of communism, universalism, disinterestedness, and organized scepticism, as the institutional imperatives that comprise the 'ethos of modern science'. Here, I will specifically focus on Merton's norm of 'communism[2]', as it bears an obvious relationship to the norms of open science, such as openness and responsiveness.

[2] Many commentators of Merton's work have referred to this norm as 'communalism' because of its political-economic connotations. Communalism also appropriately refers to a community of scientists which produces communalized products. Although communalism captures Merton's intention appropriately, I will employ Merton's original wording for purely historical reasons.

In his essay, Merton (1942) characterizes communism as follows (quotations are from the paragraph on communism in Merton's 1942 essay).

- 'The substantive findings of science are a product of social collaboration and are assigned to the community'.

- Scientific knowledge is a common property. 'The institutional conception of science as part of the public domain is linked with the imperative for communication of findings. Secrecy is the antithesis of this norm; full and open communication its enactment'.

- 'Free access to scientific pursuits is a functional imperative'.

- The scientist's claim to his intellectual property is limited to that of recognition and esteem.' The institutional consequence is that scientists pursue originality and driven by a competitive quest for priority. However, 'the products of competition are communized'. It concerns a 'competitive cooperation'.

Throughout the years, scholars have debated whether the CUDOS norms represent values for the proper functioning of the scientific system (cognitive functional meaning) or normative prescriptions and moral imperatives guiding scientists' behaviour within a lived ethos (Stehr, 1978). It can be assumed that Merton himself was aware of this ambiguity since he articulated communism both as a functional imperative for the institution of science to generate shared knowledge for the public domain through competitive cooperation, and as an ethical norm governing proper scientific conduct. Additionally, Merton stated that the CUDOS norms are not exclusive to science but can be present in any social structure. There is no demarcation criterion that distinguishes science from non-science based on a specific set of norms. The CUDOS norms represent an ethos, an idealized framework for the scientific community to strive towards rather than a fully attainable reality. Merton did not intend to codify these norms and recognized that actual scientific practices may not always align with the demands of this ethos. In other words, Merton's ethos serves as a critical yardstick for assessing the behaviour of scientists. Just as Rawls appeals to political and civic virtues of citizens in his concept of the 'public use of reason' for a just and fair society (Rawls, 1993), Merton's ethos of science relies on the cultivation of scientific virtues by members of the scientific community. For our discussion, it is important to recognize that the Mertonian norms can be viewed both as values of the scientific system for its proper functioning and as prescriptions for appropriate scientific conduct within the scientific community.

EXPLICATING THE NORM OF COMMUNISM

Below, I aim to demonstrate that the norm of communism presupposes subnorms of mutual responsiveness and openness, with social collaboration among knowledge actors as a logical consequence.

Merton asserts that scientific knowledge is a result of 'full and open communication' (as quoted above). He assumes that scientific knowledge emerges through the open sharing of outputs produced by 'competitive cooperation'. However, he does not delve into how mutual understanding can be achieved within the scientific community when dealing with conflicting scientific findings, ultimately leading to a shared understanding that can reasonably become part of the public domain. While Merton explicitly considers 'openness' in the communication structure of scientists, he does not elaborate on the normative assumptions underlying this open communication structure. Merton's openness solely relates to the public sharing and communication of knowledge, even though he anticipates an eventual mutual understanding of scientists in terms of 'certified knowledge'. Merton stated: "The institutional goal of science is the extension of certified knowledge" (Merton, 1973, page 270). The American philosopher Charles Sanders Peirce revealed the inherent communicative presuppositions of scientific research practices and communication in terms of an involvement of community of interpreters (Peirce, paragraph 311), which Habermas later generalized beyond the scientific realm to communicative action (Habermas, 1996). Habermas's insight centres on the notion that any serious contender of truth or normative claims must engage in argumentative praxis, counterfactually anticipating a mutual understanding of context-transcending claims (Habermas, 1996, p.13). This implies a norm of mandatory answerability to discussion partners. In other words, members of the scientific community who aspire, counterfactually, to adhere to Merton's norm of communism and open communication must be mutually responsive to one another's insights. While Merton reduces openness to *openness to knowledge sources* such as publications arising from competitive cooperation, a comprehensive understanding of openness encompasses an *openness and mutual responsiveness to* any member of the scientific community as *a knowledge actor*.

SELF-GOVERNANCE OF SCIENCE THROUGH COMPETITIVE COOPERATION OR GOVERNANCE BY CO-RESPONSIBILITY OF KNOWLEDGE ACTORS?

Merton perceives scientific knowledge as a product of social collaboration. However, he fails to convincingly argue that knowledge generation is the outcomes of only this specific social collaboration at the aggregate level of the system of science by means of competitive cooperation with a common benefit for the scientific community. The term 'social collaboration' should be understood more broadly. Merton's concept of competitive cooperation pertains to working within a scientific community to primarily achieve individual goals as a scientist, assuming that this is the most productive approach for the scientific system as a whole. On the other hand, collaboration involves working with other members of the scientific community to produce shared research findings and achieve collective goals.

The practice of 'mutual responsiveness' not only leads to knowledge production through argumentative discourse but also enables coordinated research actions based on a shared understanding of the subject matter. This can result in interdisciplinary or transdisciplinary research missions that go beyond the boundaries of specific scientific disciplines, fostering knowledge generation in diverse settings. If a scientific community embraces and acts upon the norm of 'openness', increased mutual understanding of scientific insights and collaborative research actions based on such understanding become possible.

Merton acknowledges that social collaboration and the adoption of social norms are not unique to the scientific community but also exist in other social contexts. He acknowledges that there is no clear demarcation between science and non-science in terms of norm adoption. Similarly, we cannot distinguish science from other collaborative contexts solely based on social collaboration. Consequently, we lack a rational basis for categorically disqualifying non-scientific knowledge actors from engaging in scientific discourse, even if they may not fully comprehend the subject matter[3]. Science can be seen as an institutionalized form of scientific discourse, which might imply specialization in scientific discourses or cooperative truth-seeking processes. However, when collaborating within science, we inevitably engage in normative discourses regarding research goals and priorities.

Merton's work primarily focuses on science at the frontiers of knowledge generation, rather than science's capacity to address societal problems. He aligns himself with those who perceive direct societal intervention in science as a distortion of its nature, alluding to the 'norms of pure science' when describing the ethos of science (Storer, 1973, page ix). Merton's contribution can be seen as a sociology of science that abstracts from the contents of scientific knowledge. Thomas Kuhn's *The Structure of Scientific Revolutions* (1962) repre-

[3] S.O. Funtowicz and J. Ravetz (2015) concluded that not only the production of knowledge should be identified beyond the scientific community but that also the evaluation of the quality of knowledge needs to be conducted by an 'extended peer community'.

sents a subsequent phase in the reception of Merton's work, complementing it with a sociology that examines the contents of science and further articulating the dichotomy between cognitive and social norms of science (Stehr, 1978). While Merton explicitly denied the existence of a demarcation criterion based on norms, post-Kuhnian sociology and philosophy of science have failed to establish a conclusive cognitive demarcation criterion. Paul Feyerabend's *Against Method* (1975) ended a search for such criterion. In line with Habermas' notion of argumentative discourse and communicative action, we cannot effectively differentiate between a scientist making a truth-claim and an ordinary citizen doing the same. However, if we wish to give substantive direction to science beyond the inherent growth of knowledge pursued by 'pure' science, knowledge actors inside and outside of science must engage not only with truth-claims but also with normative claims regarding the 'right' direction for science. Therefore, forms of social collaboration among knowledge actors within and outside of science are appropriate for any democratic society. In a post-Kuhnian and post-Mertonian world, this is effectively realized through various interfaces between science and society, such as science funding bodies, science communication institutions, and technology assessment institutions (Pereira *et al.*, 2017; Grunwald 2018).

Karstenhofer (2021) examines Merton's norm of 'communism' in the context of technology assessment practices within the science-society interface and proposes an expanded concept of communism that goes beyond the boundaries of the scientific community and includes values such as 'transparency'. Social collaboration in shaping the direction of science or aligning science with research missions that produce socially relevant outcomes becomes essential due to the increasing number of societal challenges we face. Interestingly, there is neither substantial scientific evidence supporting the functional effectiveness of Mertonian norms in science, nor there has been put forth any significant proposals for a set of alternative norms post-Merton (Storer, 1973). This also applies to the recent call for open science, where initial empirical evidence supporting the claim that open science makes research more responsive to societal demands is lacking. However, the situation has changed significantly since the COVID-19 pandemic. It can be easily demonstrated that the scientific community globally engaged in collaborative efforts related to COVID-19, with millions of data submissions on open data sharing platforms established under public policy pressures (COVID-19 Data Portal, See also the recent commissioned study by Frontiers of Spichtinger on the impact of Open Science on Covid research 2024). This collaboration in open science mode was instrumental in managing the pandemic and expediting the development of effective vaccines within an accelerated period. Such collaboration cannot be fully explained by Merton's notion of competitive cooperation. While Merton suggests that social collaboration in the form of competitive cooperation enables self-governance of science at the aggregate level, the COVID-19 case clearly demonstrates that self-governance was not a viable option for research policy.

Social collaboration can take various forms. It can occur at the institutional level within the interfaces of science and society without directly interfering with the actual research process. However, it does imply a shared responsibility of societal and scientific knowledge actors in steering science and innovation. The European Union, for example, has recently initiated funding for mission-oriented research addressing societal challenges (Horizon Europe, 2021-2027). Beneficiaries of the EU funding program Horizon Europe are required to envision collaborative research and innovation actions involving knowledge actors from the Quadruple Helix, including academia, industry, civil society, and public authorities. This type of research is characterized as co-designed and co-created with stakeholders (Mazzucato *et al.*, 2020), extending the norms of 'openness' to encompass not only knowledge sources but also knowledge actors beyond academic science. The requirement for mutual responsiveness among knowledge actors within the Quadruple Helix is particularly evident in the co-creation of research agendas, potentially enabling forms of anticipatory governance and directing science towards socially desirable outcomes (Robinson *et al.*, 2021). The process of co-creation and co-design is guided by sociotechnical imaginaries. That is, as a set of visions sustained by infrastructures, practices, and more or less shared meanings of social life which in turn reveal futures that are desirable for a society (Jasanoff & Kim, 2015, p. 4, Nordmann, 2023). These imaginaries portray desirable futures for society. Societal-challenge driven mission-oriented research can even revolve around a socio-technical imaginary itself. For instance, the notion of 'smart cities' indicates what is desirable through the use of technology and social innovation and how cities should be managed (Tironi & Albarnoz, 2021). Social collaboration includes consensus-building on problem definitions and the problem-solving capacities we intend to employ. On one hand, this can neutralize scientific dissent, for the duration of the missions, which often arises due to discipline-specific approaches and implicit problem framings (von Schomberg, 1992, and 2012). On the other hand, it can overcome one-sided problem definitions prevalent in public policy settings. For example, climate change policy historically emphasized climate mitigation strategies while neglecting climate adaptation strategies (Stehr, von Storch, 2023). The latter were relegated to science funding programs and were treated as 'alibi' research, a body of research that never constitute a basis for policy advice (von Schomberg, 1992).

In an ideal scenario, knowledge actors engaged in social collaboration within mission-oriented research would share responsibility for the potential impacts and outcomes of their research. Ongoing monitoring, foresight exercises, and technological assessments can facilitate anticipation of these impacts. These aspects reflect the broader concept of scientific governance that Science and Technology Studies scholars have emphasized in their work (Irwin, 2008; Rip, 2018). Helga Nowotny (Nowotny *et al.*, 2001) has also emphasized the emergence of a context sensitive science based on an interactive and co-evolving science-society relationship.

Therefore, we can conclude from the review of Merton's work that a comprehensive governance of science takes shape through various forms of social collaboration, extending beyond Merton's notion of competitive cooperation. Knowledge actors collectively share responsibility for the anticipated outcomes of research actions.

In summary:

- The research norm of 'openness' should encompass both knowledge sources and knowledge actors.

- 'Openness' needs to be further defined in terms of 'mutual responsiveness' among knowledge actors.

- There are no clear demarcation criteria for distinguishing knowledge actors within and outside of science.

- Social collaboration requires mutual responsiveness to the normative framing of research goals, thereby providing substantive direction to science beyond the mere growth of knowledge.

- Science governance involves a wide range of knowledge actors engaging in social collaborations with scientists to achieve desirable societal outcomes.

- The case of 'open science' during the COVID-19 pandemic illustrates that self-governance of science was not a viable option for research policy.

These observations highlight the importance of social collaboration and co-responsibility among knowledge actors to steer science towards addressing societal challenges and achieving desirable outcomes.

SELF-GOVERNANCE OF THE INSTITUTION OF SCIENCE VS SELF-GOVERNANCE BY AN ETHOS OF SCIENCE

Merton's assertion that the four norms of science are not exclusive to science is valid. He emphasized the significance of cultural norms, particularly the role of a Protestant ethic (Merton, 1973, p. 228). The interconnectedness of specific norms within society and the scientific community is relevant. Schendzielorz *et al.* (2021) also connect the scientific ethos with the democratic ethos and conclude that the Mertonian norms are best understood as a set of procedural norms for self-governance. However, Merton (1973, p. 273) argued that science can be better *fostered* in an open, democratic society than in other types of societies. The norm of civic participation in a 'democracy' is a lived ideal for citizens, just as the norm of 'communism' is a lived ideal for the scientific community. Both norms presuppose the value of 'openness'.

This highlights 'openness' not as a prescriptive norm but as a value of the institution of science. Simultaneously, 'openness' is also an institutional value of a democracy. If we primarily understand the norm of communism as an institutional value of science, then communism and openness become research virtues for the scientific community rather than prescriptive norms. Similarly, 'voting' is considered a civic virtue in a democracy, even though the institution of democracy does not oblige individuals to vote. This line of thinking aligns with Merton's rejection of codifying the four norms, which can be seen as functional for the operation of science and therefore represent institutional values. In this way, we can understand Merton's formulation as a self-governance of the institution of science through the adoption of appropriate research virtues by the scientific community.

In a post-Mertonian world, after lengthy discussions among academies of science, norms of 'good' scientific conduct have been codified. For a long time, academies of science and funding organizations primarily phrased these norms in negative terms, focusing on what constitutes misconduct in science. For example, the US Office of Research Integrity (ORI) defines research misconduct as 'fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results'. Eventually, the All-European Academies adopted a set of codified principles of research integrity and incorporated them into the European Code of Conduct for Research Integrity (ALLEA build on and extended the principles and responsibilities set out in the 2010 Singapore Statement on Research Integrity which represented the *first* international effort to encourage the development of unified policies, guidelines, and codes of conduct world-wide (Singapore Statement on Research Integrity). Since 2017, the European Commission has recognized the ALLEA Code as the reference document for research integrity in all EU-funded research projects and as a model for organizations and researchers.

It is worth noting that none of the CUDOS norms have been included in a code of conduct for researchers. In fact, the code of conduct primarily appeals to normative principles of *honesty, reliability, accountability, and respect*, with a focus on the quality of scientists' publishing behaviour rather than their actual work in their research fields. This focus on misconduct in publishing arose due to the increasing importance of publications for research careers and funding. Furthermore, the scope of codification is limited to matters of scientific integrity, even though these norms or principles have been described as fundamental to 'good' research practices. The responsibility of the scientific community is described as an overarching duty to 'promote, manage, and monitor a research culture based on the scientific integrity of its members'. (ALLEA, 2023). The implementation of scientific integrity is managed through *self-regulation by the scientific community*. This contrasts with Merton's conception of self-governance of the institution of science in which self-governance of science is achieved by a scientific community appealing to the *institutional values of science* by scientists adopting scientific virtues.

SELF-GOVERNANCE OF SCIENCE AND EXTERNALIZING ISSUES OF RESPONSIBILITY

The scientific community, represented by the Academy of Sciences, has been more reactive than proactive in formulating a set of norms for scientific integrity. Only in 2017 did they adjust an original draft of the code to address challenges arising from technological developments, open science, and citizen science. It is important to note that the value of 'openness' was added to the code subsequent to the rise of open science and citizen science. However, compared to Merton's 1942 demand for 'full and open communication', the 2017 Code is still relatively weak on open science. The European Code instead states among other: 'researchers (…) ensure access to data is as *open as possible*, as closed as necessary' and 'All partners in research collaborations agree at the outset on the goals of the research and on the process for communicating their research as transparently and *openly as possible*'.

Merton rejected Intellectual Property Rights (IPR) in research practices as a violation of 'communism' and incompatible with the integrity of the knowledge production process, a concern not echoed by ALLEA. Merton believed that knowledge generation is a common good, and the privatization of knowledge was critically viewed even in the 1940s, though it was less prevalent than today. Merton argued that personal esteem and recognition for scientific ideas should be the primary driving force. Only personal esteem and recognition for having originally proposed successful scientific ideas is what should matter and drive scientists in a competitive cooperation for a quest of priority. According to Merton, there is no better recognition and reward for a scientist than being named after a discovery, such as *Newtons* gravity laws.

Furthermore, it is worth noting that the scientific community only agreed on codes of conduct as tools for self-governance due to external pressure from science policy, science funders, and societal demands. The scientific community did not initiate the initiatives to codify scientific practice themselves. The community has long feared losing control over its own governance to societal interference, leading to a delayed and limited response to 'open science' after it was already adopted a formal public policy (European Commission, 2015). In a case of less public attention, the scientific community did not wish to give any substantial follow-up to regulatory measures such as the European Commission's recommendation to adopt a code of conduct for responsible nano sciences and nanotechnologies research (2008), a code which stated social responsibilities for among other human health, environmental safety, and human rights, going far beyond matters of research integrity.

Merton was equally worried about of a form of 'responsibility' science should not get burdened with. But he argued for this position more consistently than the Academies of Sciences, who stand in his tradition, currently do. ALLEA silently embraces a broad set of IPR within the research context while rejecting any responsibility for the social outcomes and impacts of science and technology. Merton, on the other hand, argued against holding science responsible for outcomes it could not foresee or prevent. He advocated for a 'pure' science whose primary function is knowledge growth, regardless of whether the resulting knowledge proves beneficial to society. In an IPR-free research context driven solely by scientists' pursuit of recognition and esteem, the integrity of the scientific system would be guaranteed.

He commented on the fear in the 1940s that new technologies would cause a loss of jobs and the broad public concern with the negative outcomes of technological advance as follows (italics are mine):

'Precisely because scientific research is not conducted in a social vacuum, its effects ramify into other spheres of value and interest. Insofar as these effects are deemed socially undesirable, science is *charged with responsibility*. The goods of science are no longer considered an unqualified blessing. Examined from this perspective, the tenet of pure science and disinterestedness has helped to prepare its own epitaph. Battle lines are drawn in terms of the question: can a good tree bring forth evil fruit? Those who would cut down or stunt the tree of knowledge because of its accursed fruit are met with the claim that the evil fruit has been grafted on the good tree by the agents of state and economy'. (Merton, 1973, p. 263)

The state of science in 2023 is different. The sciences have evolved over the decades post-Merton and are now intertwined with societal and industrial interests. Merton's image of science as primarily aimed at explaining or understanding natural and social phenomena has been subject to change, with many sciences adopting an engineering perspective. Biology, for example, now includes engineering practices that were unimaginable during Merton's time. Graig Venter brought this to a point in an impressive keynote lecture on the question 'What is Life' at a ESOF conference in Dublin (Venter, 2012). His answer: 'I will understand it when I can create it'. Hence his preoccupation with engineering a synthetic self-replicating living cell. The engineering perspective has permeated almost all natural sciences, resulting in outcomes that are increasingly a matter of creation and design. We now even anticipate the social and physical consequences of technological products and use phrases like 'safety by design' (nanoscience) and 'privacy by design' (computer sciences). This engineering perspective brings the issue of responsibility internally to science itself, as the ability to create or design implies responsibility for the outcomes. The traditional full 'externalization' of responsibility for the outcomes of the science to politics and the economy as Merton suggested is nowadays untenable from the perspective of a *responsible* engineer. This is also echoed in the history of various codes of conducts, national and scholarly societies of engineers have adopted over time. These codes, in contrast with the code of the Academies of Sciences, have not refrained from adopting social responsibilities, including addressing the safety and welfare of the public and, most recently, adopting principles of sustainable development (for a comprehensive overview, see Mitcham (2020), chapter 16).

This shift towards engineering practices within the sciences has resulted in a less engagement with the research value of 'openness'. Engineering sciences often produce inventions rather than scientific discoveries, and inventions are closely associated with intellectual property practices, as only inventions can be patented, not scientific discoveries. The engineering perspective integrates better understanding of natural phenomena with creations and inventions.

For example, Nobel Prize winner Feringa's construction of a molecular-driven 'nano car' demonstrates the connection between inventions and a better understanding of natural laws:

> 'The driving force behind the project was the desire to *figure out* how to get an entirely synthetic, single-molecule system to move on its own across a surface' (…) Probably future *designs* will be different from what we show here, but we have to *demonstrate the fundamental principles*. (Citation of Feringa in *Chemical and Engineering News*, 2011).

In a similar vein, Graig Venter has 'figured out' how a better understanding of biology contributed to the creation of a self-replicating synthetic bacterial cell. Graig Venter has filed dozens of patents for his 'inventions' including the generation of synthetic genomes. (Venter, the Patents of Graig Venter). The increasing specialization within the sciences and the rise of engineering have introduced issues of responsibility explicitly into the sciences, particularly in terms of responsibility for designs. Consequently, this implies a decrease in the importance of 'openness' for the functioning of the system of science. Mitroff (1974) formulated on the study of Apollo moon scientists Mertonian counter norms, e.g., particularism, secrecy, organized dogmatism, and selfinterestedness. Instead of focusing on knowledge generation and sharing, engineers lay a greater emphasis on knowledge mobilization and acquisition to create things like nano cars or synthetic cells. This shift reflects a departure from Merton's concept of pure sciences.

However, we can view engineering sciences as a form of science, which relies on, and benefits from sciences that aim primarily to enhance our understanding of natural and social phenomena. Therefore, the engineering sciences are beneficiaries of a scientific system that strives to be as open as possible[4]. With the emergence of 'open science,' there is also a contrasting trend to the trend of the uptake of an engineering perspective, namely the emergence of interdisciplinary sciences benefiting or even basing itself on an open science rationale. Climate scientists, for example, seem to operate to a significant extent on the basis of an open science rationale of open data sharing. In this case, empirical research has demonstrated that climate scientists are still ethically guided by Mertonian norms, but the current system of science incentives them to deviate from these norms with, among other, 'a tendency to withhold results until publication and the intention of maintaining property rights (Bray & von Storch, 2017). Paradoxically, these relative open science interdisciplinary research practices have emerged against the background of an ever-increasing specialization and proliferation of disciplinary approaches in the sciences post-Merton, based on specific epistemic cultures and specific paradigms. These scientists see themselves predominantly as members of a scientific discipline rather than the scientific community as such. 'Openness' becomes then at best a virtue of a scientific discipline. Karin Knorr-Cetina's anthropology on epistemic cultures (1999) even put in question the unity of the sciences.

[4] I cannot extensively deal here with the notion of open innovation, which also effects the engineering sciences despite their ambivalence towards openness. In parallel to Open Science, Open innovation is essentially based on the innovation as a collaborative networked activity. Benkler (2017) adequately summarizes and captures the various shifts towards open innovation practices whereby innovation is primarily an emergent property of knowledge flows, sharing, and collective learning in communities of practice and knowledge networks rather than a result of traditional individual and firm-based innovations. Benkler (2017) also notes a shift from pure market-driven innovations to innovations that are driven by social motivations and public investment.

TOWARDS A NEW ETHOS OF THE SCIENTIFIC COMMUNITY OR AN INSTITUTIONAL REFORM OF SCIENCE?

In light of these considerations, the question arises: should we focus on self-governance of the scientific community through a set of prescribed norms or on the self-governance of the institution of science through a set of institutional values? Theoretical discussions on this matter may not yield a conclusive answer. However, empirical evidence dismisses the notion of self-governance by either the scientific community or the institution of science.

Firstly, it is evident that science governance is influenced by a wide range of knowledge actors who engage in social collaborations with scientists to achieve desirable societal outcomes. This collaboration entails the civic virtue of openness and demands for the participation of knowledge actors in a democracy, aligning with the virtues of openness to diverse knowledge sources in science. It also signifies the willingness of actors to share responsibility for the anticipated outcomes of research and innovation. Secondly, the issue of responsibility has not only been raised by external knowledge actors but also by the sciences themselves, which are increasingly dominated by an engineering perspective. Instead of adhering to the Mertonian norm of 'disinterestedness', scientists and engineers advocate their work in terms of its potential societal impact, for example, by taking on '14 game-changing goals for improving life on the planet', ranging from 'advancing personalized medicine to reverse-engineering the human brain and addressing cross-cutting themes of sustainability and joy of life' (Venter, Engineering Challenges). Constraining the issue of responsibility solely to science-internal codified norms of scientific integrity or to competitive cooperation among knowledge actors for knowledge growth, as proposed by Merton, contradicts the empirical reality of the 21st century. In practice, we are evolving towards a system of co-responsibility through social collaboration between scientists and external knowledge actors, as well as steering science in the desired direction through science-society interfaces, including science funders, charitable organizations like the Gates Foundation and technology assessment offices.

THE CO-RESPONSIBILTY OF SCIENCE GOVERNING ORGANIZATIONS

Having settled the issue of self-governance in favour of co-responsibility between knowledge actors and science governing bodies at the science-society interface, we still face the question on how we could now ensure that our extended notion of 'communism' in terms of openness and mutual responsiveness can be adopted by either the institution of science as a set of values, or by an extended ethos of science of the scientific community. Consistent with our analysis, any such a change has to come from the science-society interface. Research funders will have here a responsibility as they co-define the rewards and incentives system together with the employers of scientists. As science funders occupy a significant role as co-responsible actors at the science-society interface, they must consider how to promote open science if that is the type of science they wish to foster. To address this question, I will first examine the evolving practice of open science before returning to the conceptual level.

During the largest Ebola outbreak in history, a group of international researchers sequenced three viral genomes from patients in Guinea. The data was made public that same month, and this open scientific practice facilitated the availability of experimental vaccines within a short period. This approach proved vital in combating relatively smaller outbreaks in 2018.

The case of Ebola demonstrates that when faced with a public health emergency, it is crucial not to rely solely on the moral initiative of a few researchers. The institution of science demonstrated a system-failure by its inability to respond timely to urgent societal demands. The conventional process of publishing articles and patenting vaccines is inadequate in such situations. I have previously discussed how this system-failure is associated with both a productivity crisis and a reproducibility crisis in the sciences[5] (von Schomberg, 2019).

Science governing organizations initially responded to emerging public health issues such as Ebola and Zika by addressing the system failure within science in a limited manner. For example, the National Institutes of Health in the United States began requiring grantees to make large-scale genomic data publicly available no later than the time of publication. The World Health Organization (WHO, 2015) advocated for a paradigm shift in information sharing during public health emergencies, moving away from embargoes and toward open sharing using suitable pre-publication platforms. The WHO recognized that patents on natural genome sequences could inhibit further research and product development, urging research entities to exercise discretion in patenting and licensing genome-related inventions to avoid hindering progress and to ensure equitable benefit sharing. The organization also called on scientific publishers to encourage or mandate the public sharing of relevant data rather than penalizing it. However, it was not until the COVID-19 pandemic that science funders, publishers, and industries took more rigorous steps toward open science under pressure from public authorities and funding institutions.

The system-failure of the institution of science to deliver timely on socially desirable outputs, such as vaccines, underscores the need to move beyond relying solely on the moral initiative of a restricted group of researchers. We can not just simply extend Mertonian norms with an extended set of codified norms which included *norms* for 'openness' and 'mutual responsiveness.' Therefore, a reform of the institution of science is

[5] The 'reproducibility' crisis (in which scientists have increasingly difficulties to reproduce the research findings of their colleagues) comes together with a 'productivity' crisis which are linked to an increasingly competitive closed science. Research efforts (in terms of financial investments) have increased exponentially during decades whereas research productivity has dropped dramatically. Bloom *et al.* (2020) found that 'since the1930s, research effort has risen by a factor of 23 — an average growth rate of 4.3 percent per year'. However, research productivity (in terms of economically viable and socially desirable innovations) has fallen: 'by a factor of 41 (or at an average growth rate of -5.1 percent per year') (Bloom *et al.*, 2020, p. 7).

due which aims at an institutionalization of the *values* of openness and mutual responsiveness, by an overhaul of the rewards and incentives system. To put it in a simplified form: if scientists are rewarded and incentivized to do the 'right' thing, then the majority of the scientist will most likely do so independent whether they appreciate particular Mertonian norms or whether they remain full skeptical about adopting any form of ethics. A new incentives system that rewards scientists who work in an open and collaborative mode will institutionalize the values of 'openness' and 'mutual responsiveness' for a better functioning of the scientific system. The shift from a closed form of science to open science is a necessity for enabling the institution of science to respond timely, not only to emerging public health issues, but to all urgent societal challenges. Co-responsibility of science-society interfaces for science governance implies institutional aspects and a change in the science-society relationship (see also Bijker *et al.*, 2022) who have advised on among other, how the value of 'openness' for responsible biosciences could be considered in the framework of a revised science-society contract). I have elaborated elsewhere that rewarding open science implies a shift from primarily rewarding scientific outputs such as publications to rewarding research behavior such as knowledge and data sharing and social collaboration prior to publishing (von Schomberg, 2023).

The European Commission thus took the right decision to initiate a reform of the institution of science rather than focusing on a new ethos of science (European Commission, 2015). It was only in January 2022, after extensive preparatory work by the European Commission, that a coalition of over 350 organizations from more than 40 countries, including public and private research funders, universities, research centers, institutes, and university associations, eventually agreed to *initiate* a reform process (CoARA) (which builds on, among other, the 2012 self-regulatory initiative of individual researchers and research governing organization: the

San Francisco Declaration on Research Assessment, DORA, 2012). The intention is to transition to a research assessment system that emphasizes a qualitative approach within the framework of traditional peer review. However, it remains to be seen if institutions are willing to significantly shift from a system that primarily rewards research outputs to one that rewards research behaviour. Institutions often hide behind the cherished 'autonomy' of universities and research institutions, claiming a Mertonian heritage of pure science that no longer exists.

Based on our review of Merton's legacy, we can now propose a reformulation of the science-society relationship, emphasizing the co-responsibility of knowledge actors as knowledge co-producers and the involvement of a broad range of science governing institutions at the science-society interface. Merton stated, 'The scientist came to regard himself as independent of society and to consider science as a self-validating enterprise which was in society but not of it' (Merton, 1973, p. 268).

Building upon our review, I propose the following rephrasing: The scientists came to regard themselves as knowledge co-producers and consider science as a co-validating enterprise that is in society and with it. Furthermore, Merton stated, 'When the institution of science operates effectively, the augmenting of knowledge and the augmenting of personal fame go hand in hand' (Merton, 1973, p. 323). In light of our analysis, we can conclude that 'when the institution of science operates effectively, the augmentation of knowledge and its relevance for addressing societal challenges go hand in hand'.

OUTLOOK AND DISCUSSION

The COVID-19 pandemic has greatly accelerated the adoption of open science practices, which now permeate all stages of the research process. Open science entails the active involvement of all relevant knowledge actors, fostering co-production from research agenda setting to scientific discovery and analysis. Among other, the utilization of open notebooks enables real-time data sharing, while open peer-review and knowledge dissemination promote wider outreach (von Schomberg 2019, Burgelman *et al.*, 2019, Miedema, 2021).

A radical open science practice entails an unprecedented level of openness that could not have been conceived by Merton in 1942. As noted by Hosseini *et al.* (2021), this openness encompasses not only knowledge but also various data and code and allows for real-time communication rather than waiting until the point of publication. Consequently, the traditional Mertonian incentives system, which emphasizes the 'quest for priority', becomes inapplicable to a radical open science practice. The Covid-19 pandemic has highlighted the importance of early information sharing among researchers, implicating a loss of originality at the time of publication. Consequently, I propose a shift in the rewards and incentives system, moving beyond solely focusing on research products like publications, to considering research behavior that aligns with research missions, such as collaboration and mutual responsiveness among knowledge actors. This new system would incentivize research institutions, such as universities, based on their contributions to collaborative research missions, thereby enhancing the productivity of the scientific enterprise. The function of the institution of science is not to deliver 'certified knowledge' as defined by Merton's 'pure' sciences but should encompass the generation of knowledge that addresses societal challenges, produced by a post-normal science characterized by significant scientific uncertainty and epistemic dissent (Ravetz & Funtowicz, 1993). Currently, the emphasis on individual researchers maximizing research outputs, such as publications, paradoxically hampers the overall productivity and responsiveness of the scientific community in tackling societal challenges. The prevailing irrational competition among universities to lead in terms of publication numbers and venues is reflected in a multitude of university rankings. While these rankings receive little public intellectual support, universities proudly promote their scores.

It is crucial to acknowledge that the current prevailing understanding and implementation of 'open science' by publishers, universities, and research policies do not align with comprehensive open science practices. Instead, the focus often narrows to the realm of 'open access' for publications and data. The open access policies currently being incrementally implemented by major scientific publishers, encouraged by research funders, can be viewed as mere adjustments to their business models.

The prevailing 'gold open access model,' favored by wealthier nations, relies on an author-pay system, effectively creating a situation where only scientists financially supported by their institutions can afford to publish in leading journals. Consequently, this may lead to a scenario where scientists prioritize to work for institutions that provide support for their publications. However, this publishing model contradicts the open science practice of sharing knowledge prior to publication. A notable example of such pre-publication sharing was already observed during the Human Genome Project, where data on the human genome was widely disseminated among the scientific community throughout the project, while there was a temporarily moratorium on publishing to encourage optimal collaboration, rather than competition.

Research conducted by Cole *et al.* (2023) has demonstrated that the unequal access to resources resulting from the current predominant open access publishing model confers distinct advantages upon certain scientists, thereby perpetuating inequities in the system that genuine open science practices aimed to eliminate. Furthermore, it restricts the ability of non-scientific knowledge actors to publish in scientific journals, creating a new form of exclusivity. Open access publishing, often accompanied by promises of higher citation rates, reinforces the traditional emphasis on individual productivity within the scientific community, rather than fostering the overall functioning of the scientific institution through collaborative efforts to address societal challenges.

Research assessments that reward research productivity based on the number of publications and citation rates further reinforce a limited understanding of 'openness,' reducing it primarily to publications. This type of 'open science' violates the Mertonian norm of communism and our extended interpretation of it, which emphasizes openness and mutual responsiveness to both knowledge sources and knowledge actors.

In table 1, I have summarized the positions attributed to Merton, the current state of affairs and the author of the article.

Table 1. Positions attributed to Merton, the current state of affairs and the author of the article.

	Merton	Current State of Affairs	Author of the article
Normative structure of the Scientific community	Ethos of Science-CUDOS norms	Research Integrity IPR regimes for entrepreneurial science	Research behavior: social collaboration and knowledge sharing, comprehensive open science rationale
Normative Structure of the Institution of Science	Institutional values cultivated by Scientific virtues	Financial framework for macro-economic benefits- aligned with national innovation systems	Institutional values including openness and mutual responsiveness, cultivated by scientific virtues of open science
Governance of the Scientific Community	Self-governance by ethos of science	Code of conduct for research integrity	Social collaboration in co-responsibility mode among knowledge actors
Governance of the Institution of Science	Competitive collaboration/quest of priority	Competitive 'research excellence' funding. Commodification of Science by Industry	Science-Society interfaces to provide direction to research and innovation
Function of the Scientific Community	Augmentation/growth of knowledge	Scientific discipline-based production of knowledge	Research missions addressing societal challenges
Function of the Institution of Science	Certified knowledge	Knowledge generation with view on societal and economic benefits	Societal Challenge based knowledge generation
Rewards and Incentives System	Originality as sole driver. Establishment of recognition and esteem in the scientific community of individual researchers	Quantitative and qualitative Productivity and Quality metrics of individual researchers	Relative contribution to research missions of research Institutions. Promotion of research behaviour: knowledge and data sharing, social collaboration among knowledge actors

Source: elaborated by the author (von Schomberg, 2024).

A topic that warrants further investigation is the potential mutual reinforcing dynamics between openness and mutual responsiveness as institutional values within both the spheres of science and democracy. My hypothesis is that social collaboration at the intersection of science and society enhances the quality of societal problem-solving capacities and facilitates the generation of knowledge for addressing societal challenges. This characteristic might be essential for a deliberative democracy seeking to revamp its governance models while confronting new challenges.

Responsible research and innovation (RRI) have emerged as a response to governance deficits in science and technology. RRI calls for a form of governance that directs science towards socially desirable outcomes or manages innovation processes to increase the likelihood of such outcomes. (Stillgoe *et al.*, 2013; Macnaghten 2020; Owen *et al.*, 2021). This approach encompasses credible research (through codes of conduct and standards for scientific integrity), responsive research (by a shift to open science and engaging with societal demands), and responsible research (including the anticipation of socially desirable outcomes by integrating foresight and technology assessment within research missions). Similar principles apply to credible, responsive, and responsible innovation (von Schomberg, 2019).

Despite the growing recognition of RRI, there are still limitations in our capacity to implement its ambitions. Research funders, such as the European Commission, have taken steps to support mission-oriented research that tackles societal challenges, enabling knowledge actors from various domains to share co-responsibility in social collaborations and anticipate socially desirable outcomes. The White House has also recently introduced measures to promote responsible AI innovation (WH, 2023). However, for these initiatives to have a meaningful impact, it is crucial to establish a rewards and incentives system that makes open science, with its core principles of openness and mutual responsiveness, the norm rather than the exception. Instituting such an institutional reform is a necessary condition for effectively implementing responsible research and innovation.

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When Science Becomes Engineering

Commentary on "Towards a New Ethos of Science or a Reform of the Institution of Science? Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness" by René von Schomberg.

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The core insight of this thoughtful and provocative article is that science has become engineering and must be re-governed appropriately. Science today is as much artefact constructing as it is knowledge-producing. Certified knowledge is found through certified construction; science has become technoscience. As such, received practices of and models for governance need re-examining.

It is not possible here to address the full range of insights and questions that René von Schomberg's challenging paper puts on the table. His argument is clearly the outgrowth of years of critical reflection in the science policy trenches of the European Commission. I would wager that there's no one who has thought longer, harder, and at greater depth about these issues. I will concentrate my comments on the question concerning engineering.

Von Schomberg frames his argument as a reconsideration of Robert Merton's argument from the 1930s and 1940s in defence of four ideal norms he called the ethos of the scientific community.

Distinct but not unrelated to epistemic norms such as testability, consistency, and simplicity, Merton argued, are social, behavioural norms of sharing research results, allowing universal participation, not letting experimental goals distort the interpretation of results, and the cultivation of repeated questioning of claims by oneself and others. Historically this was a time in which the Enlightenment view of science as an unqualified dual benefit for humanity – liberating people from myth and superstition and conquering the age-old ills of disease and poverty – was still credible. Although the relationship between engineering and science was more complex than any simple application, it still served the interests of both parties to adopt the model as a reasonable approximation. Pointing to engineering and technological "applications", science could claim purity, neutrality, and indirect credit for the world-transforming benefits that came to life in the Industrial Revolution and after while absolving itself of responsibility for harms. Claiming that it was "applying" the truths of science, engineering could disguise its captivity to capitalism and the military. The naiveté of the ideology that combined scientific purity with progressive material benefit was dramatically exploded by the 1945 detonations of atomic bombs at Hiroshima and Nagasaki.

As Hans Bethe recalled his feelings after Hiroshima, "The first reaction which we had was one of fulfilment. Now it has been done. Now the work which we have been engaged in has contributed to the war. The second reaction, of course, was one of shock and horror. What have we done? What have we done? And the third reaction: It shouldn't be done again." (*Day After Trinity*, 1981) In the words of Michel Serres, "For the first time since its creation, perhaps since Galileo, science – which had always been on the side of good, on the side of technology and cures, continuously rescuing, stimulating work and health, reason and its enlightenments – begins to create real problems on the other side of the ethical universe" (Serres, 1995, p. 17).

That third reaction led to creation of multiple movements for social responsibility, first among a few nuclear physicists who had unwittingly become engineers not just of weapons of mass destruction but of power plants of catastrophic (but low probability) risk. Shortly this taking up of responsibility spread among other practitioners unwittingly engineering-infused fields such as conservation biology (see Rachel Carson) and genetics (see Asilomar Conference) – as well as among engineers themselves, although not always by engineers who publicly identified as such. In the United States opposition to the engineered (both technically and politically) War Against Vietnam intensified the issues.

When Merton analysed the emergence of social criticisms of science he focused on oppositions to the ways science as knowledge can challenge and disturb customary beliefs and is itself open to distortion when subject to manipulation by evil politics (antisemitism and racism) or stupidity (Lysenkoism). I don't think engineering is even mentioned in Merton's ethos of science papers; the word doesn't occur in the index to the collection of Merton's sociology of science papers (Merton, 1973). Yet, during the very same period, professional engineering societies in the United States were beginning a process of self-reflection that would lead to the reformulating engineering social behavioural norms in light of increasing recognition of the ways society was become an engineered and engineering world and engineers were becoming consequential actors in the political world.

Classically, in conjunction with construction norms such as efficiency, safety, and durability, engineers had assumed social obligation norms such as loyalty to employers and avoidance of conflict of interest. By the end of World War II, this engineering professional self-reflection had replaced the ethos of company loyalty with one of public safety, health, and welfare. It may be useful to recall this process, precisely because it was so ignored in the scientific community while being so relevant to what was happening in the transformation of science.

"In 1947 the Engineers Council for Professional Development (ECPD) – founded in 1932 as an organisation of organisations (not of individuals), and charged in part to develop an ethics code acceptable to its constituent engineering societies – adopted an ethics code that made it a leading duty for engineers "to interest [themselves] in public welfare" and to "have due regard for the safety of life and health of the public". Revised in 1963, 1974, and 1977, this code eventually formulated the first of seven "fundamental canons" as follows: "Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties".

In 1980, the educational supervising activity of the ECPD was restructured into the Accreditation Board for Engineering and Technology, now simply called ABET, to certify engineering degree programs. ABET assumed the final ECPD revision of its code, along with an extended "Suggested Guidelines for Use with the Fundamental Canons of Ethics". In this form the ABET code influenced engineering education, insofar as ABET slowly began to stress the importance of professional ethics in university engineering curricula...

A further illustration of the post-World War II emergence of the importance of social responsibility in engineering ethics was a code developed by the National Society of Professional Engineers (NSPE). Like the ECPD, one of the original objectives of the trans-disciplinary NSPE, founded 1934, was "the establishment and maintenance of high ethical standards and practices". Unlike the ECPD, which was an organisation of organisations, the NSPE is an NGO of something like 50,000 individual members, all of whom are Professional Engineers (PEs). According to its mission statement, the NSPE "promotes the ethical and competent practice of engineering, advocates licensure, and enhances the image and well-being of its members".

Although an ethics code was proposed as early as 1935, none was formally adopted until 1946, when the NSPE endorsed the new ECPD code even before the ECPD formally did so. With the 1963 revision of the ECPD code, however, the NSPE moved to create its own code. The evolution of this distinctly NSPE code led by 1981 to the adoption of a short list of "Fundamental Canons," the first of which is to "Hold paramount the safety, health and welfare of the public". (Mitcham, 2020, p. 164-165)

Drawing on this narrative and years of teaching engineering ethics at engineering universities, I would add a fourth column to von Schomberg's matrix of governance options.

Table 2. Professional Engineering.

Normative structure of the engineering community	Engineering conduct: Employee-employer co-constructed to mesh technical power with corporate economic profit
Normative structure of the institution of engineering	Engineering values: Effectiveness efficiency; creating and protecting intellectual property (patents, trademarks, copyrights, and trade secrets)
Governance of the engineering community	Engineering codes of ethics and corporate codes of conduct (formal and informal)
Governance of the institution of engineering	Engineering-corporate-government military interfaces; technical engineering and product safety standards enforced by administrative, civil, and criminal law
Function of the engineering community	Defends professional autonomy of and promotes public appreciation of engineers and engineering
Function of the institution of engineering	Design, construction, and management of the engineered and engineering techno-lifeworld
Rewards and incentives system	Financial remuneration, professional prestige, and "existential pleasures of engineering"

Source: author elaboration based on von Schomberg paper.

Intimations of this column can be found already in a piece co-authored with von Schomberg (Mitcham & von Schomberg, 2000). Developing it here is, to some degree, simply saying something he already knows.

Each line in this new column calls for qualifying comment. As a general point, an "engineering community" does not exist with the clarity and self-consciousness of the scientific community; it is no accident that Merton does not even mention engineering and that the sociology of engineering is an orphan discourse.

It's difficult to distinguish community and institution in science – even more so in engineering. What is the difference between an institution and an organisation? Engineering is deeply embedded, even willingly in bed with and at the service of corporate and nation-state (especially military) interests. The normative structure of engineering is an echo of the normative structure of corporate interests and the social order in which the corporations exist. The autonomy of engineering is a poor cousin to the autonomy of science – which, in fact, is rather constrained. One major driver for the creation of professional engineering societies and engineering codes of ethics has been to assert some minimal independence of corporate power. Just witness the effort that has to be expended to moderate nationalism in scientific organisations.

Precisely because of its embeddedness in corporations and nation-states, the governance of engineering is naturally more legal than is the case with science. Technical standards are, in principle, established by engineers but largely under the purview of legislative, executive, and/or judicial authorities and then enforced by state-based regulatory agencies – only rarely by international regulatory agencies. Law has more traction in engineering than in science. In the neoliberal state enforcement often devolves onto corporate self-enforcement, but almost never into professional engineering enforcement. Engineering enforcement is mostly subservient to corporate rather than engineering interpretations of relevant legal standards. There are more lawyers than scientists or engineers in the U.S. Environmental Protection Agency. When engineers complain they are marginalised or professionally driven to become whistleblowers, they are seldom defended by state power. As Winston Churchill would have put it, engineers are "on tap, not on top."

Yet engineering is the "primary productive force," as Deng Xiaoping would have put it. It is not just science that has become engineering (von Schomberg's insight) but human existence today; our lifeworld is now engineered, and we cannot help but imagine ourselves in engineering terms or as engineers *manque*, though we seldom thematise as such. It's not just that science has been infused with engineering (again, von Schomberg's point) but that "application" of science takes place through engineering methods like those used to construct the engineering sciences (mechanics, statics, dynamics, thermodynamics, electronics, etc.). Engineering design methods have become operative in our own individual, liberally constructed life projects. It is not science but the engineering sciences that are the foundation of material culture.

Rewards and incentives in engineering: On top of the normal rewards of wealth and recognition, the Hegelian "master and slave" dialectic is at work in what engineer philosopher Samuel Forman (1976) celebrated as "the existential pleasures of engineering". Engineers take pleasure and satisfaction in making and constructing things that work, in making things happen, that enter the world with power. Recall Bethe's first response to Hiroshima.

Independent of all qualifications, the fourth in the column constitutes a governance option that is closer to and provides implicit commentary on the third. A fuller development of that commentary needs to be left for another occasion. However, beyond the question concerning engineering, and speculation about how the governance of engineering may have implications for thinking about the governance of science, there is the question concerning governance. The liberal attempt and tendency to replace thinking about government and nation-state power with processes of governance implicates engineering and more. "Governance" connotes an idealist or liberal effort to step away from the realities of power. When asked to explain the difference between governance and government, ChatGPT responded:

> Governance refers to the processes, systems, and practices through which decisions are made, authority is exercised, and accountability is maintained within any organisation or society. It encompasses a broader concept than government, involving multiple stakeholders and institutions.

Government refers to the formal institutions and structures through which a country or community is ruled. It includes the political authority, elected officials, and administrative organisations that exercise executive, legislative, and judicial powers.

Note the absence of references to power in the description of governance. The shift in public discourse from government talk to governance talk constitutes a typically Enlightenment effort to replace power with rational self-regulation (the cybernetically engineered system can be taken as a paradigm). It is a liberal ideal that the real experience of the governance of engineering might suggest questioning.

As I've argued elsewhere (Mitcham, 2021), the liberal science policy ideal of governance by public participation, as it has developed in response to democratic criticisms of the elitist model articulated in Vannevar Bush's *Science: The Endless Frontier* (1945), is severely weakened by mass disaffection to such participation. People who for whatever reason – too busy, too tired, too interested in other things, too much aware they don't know enough, too much want to be left alone – don't want to be involved, can easily experience attempts at persuasion or enticement into participatory governance as liberal hypocrisy. The same liberals who valorise freedom want to limit the liberty not to do so, of those who don't want to contribute to the governance of science. In light of the structural fact that they will often be "punished" by scientific interests or corporate power when they don't participate, it can seem quite reasonable to turn to authoritarian figures who promise relief.

As indicated at the beginning, von Schomberg's account of the fate of Merton's ethos of science as science becomes engineering strikes me as one of the most insightful and provocative around. Perhaps I have contributed to the provocation, if not the insight.

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The Promises of Responsible Open Science: Is Institutionalization of Openness and Mutual Responsiveness Enough?

Commentary on "Towards a New Ethos of Science or a Reform of the Institution of Science? Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness" by René von Schomberg.

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INTRODUCTION

Von Schomberg offers a compelling examination of key open science principles and their potential role in fostering responsible research and innovation (RRI). Utilizing Merton's Ethos of Science framework, the paper constructs a series of arguments supporting a central thesis: "the transition towards open science is vital to facilitate RRI." This transition necessitates significant institutional reforms within the scientific community and adjustments to incentive structures that promote the adoption of open and mutually responsive practices.

The manuscript reframes the discourse surrounding responsibility and responsiveness in light of the evolving landscape of open science, shifting the focus from normative commitments to actionable frameworks in research and open science practices. Overall, the position paper strives to bridge the gap between idealised models of scientific communities based on RRI principles and the reality of actual scientific endeavour (Anderson *et al.*, 2007; Politi, 2021, 2024).

However, it is important to acknowledge certain omissions that could enrich the analysis. Firstly, a more comprehensive examination of the profound crisis facing science amidst the increasing marketisation and commodification of academia and research would provide valuable context beyond discussions of system failures related to productivity and reproducibility. Secondly, a more nuanced and critical approach to conceptualising open science would enrich the discussion, considering its multifaceted nature and potential pitfalls. Thirdly, the validity of the Mertonian framework and its selective analysis of values, particularly its exclusive focus on the norm of communism. Lastly, a deeper exploration of the challenges and promises inherent in the pursuit of responsible Open Science within ongoing institutional processes.

The following sections provide further details on these aspects, highlighting how von Schomberg's contribution opens the Pandora's box about the challenges and promises of a Responsible Open Science.

1. EXPLORING OPEN SCIENCE, NEOLIBERALISM, AND RESEARCH MARKETIZATION AMIDST THE SCIENCE CRISIS

The intricate and evolving terrain of Open Access and Open Science,[1] alongside the emergence of a new scientific ethos, necessitates consideration of the profound influence exerted by the neoliberal context and the proliferation of the academic capitalism[2] (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2008; Kauppinen, 2012; Hackett, 2014; Jessop, 2018; Slaugther, 2020).

Several authors have thoroughly scrutinized the growing commodification of academic research and the shifting ethos within the academic profession (Radder, 2010; Cantwell & Kauppinen,

[1] For a detailed description of European policy milestones and evolution from Open Access to Open Science in Europe see the Chapter 6 written by Carla Basili in *Science, Innovation and Society: achieving Responsible Research and Innovation*, Deliverable 3.3 Stocktaking Study (pp. 124-152).

[2] The concept of academic capitalism started in the 1990s with the publication of Slaughter and Leslie (1997). Hackett, a colleague of the aforementioned authors, claims to have coined the term to describe, at that time, the emerging circumstances within engineering and academic sciences in the United States (Hackett, 2014).

2014; Cantwell *et al.*, Bauwens *et al.*, 2023). Academic capitalism represents a shift in universities and research institutions from a model centred around the public good of knowledge and learning – guided by the ideal of the Mertonian Republic of Science – to a model where institutions, faculty inventors, and corporations prioritise their own interests over those of the public, viewing knowledge as a commodity to be capitalised upon. Science and higher education organisations have been progressively pushed towards the corporate archetype and have witnessed an instrumentalisation of knowledge and the establishment of a culture of performativity justified by the belief that economic growth, especially driven by technological innovation, will benefit society as a whole (Slaugther, 2020; Slaughter & Rhoades, 2008). Numerous studies examined the impact of market forces on science values and norms related to aspects such as the pursuit of efficiency and competitiveness, precarisation of academic labour, as well as recurrent complaints about the replication and reproducibility crisis, and the extent of fraud and misconducts in several science fields (Martinson *et al.*, 2005; Anderson *et al.*, 2007; Fanelli 2009; Begley, 2013; Marco-Cuenca *et al.*, 2021; Carvalho *et al.*, 2022). The crisis in science encompasses a decline in the quality of generated knowledge content, coupled with a diminishing credibility and relevance, and claims for a deepen ethical reflection on the values, structures, incentives, and underlying academic practices (Hasselberg, 2012; Macleod *et al.*, 2014; Jessop, 2018; Dominik *et al.*, 2022).

Jessop (2018) specifically criticises how academic capitalism affects the creation and sharing of knowledge, contending that the commercialisation of research has led to prioritising financially lucrative projects over socially significant and intellectually robust scholarship, thereby compromising the integrity and autonomy of academic investigation. Radder[3] (2010) refers to a pervasive transformation of academic culture, emphasising that "the commodification of academic research is not

[3] Radder (2010) considers that academic commodification is part of a comprehensive and long-term social development often described as the economisation, or economic instrumentalisation, of human activities and institutions, or even entire social subsystems. From a theoretical perspective, he distinguishes between three ideal-typical models: commodified science and the alternatives of autonomous and public interest science.

strictly novel but has substantially increased and intensified during the past thirty years" (Radder, 2010, p. 9). The creation of research lobbies and university alliances contribute to change the game of cooperation and competition where there are clear winners and losers, affecting core values such as academic freedom, objectivity, and integrity (Bok, 2003; Churchman, 2002; Hasselberg, 2012; Cantwell & Kauppinen, 2014; Jessop, 2018). In his paper "The Democratisation Myth and the solidification of Epistemic Injustices", Knöchelmann (2021) discusses how the commercial Big Deal Open Access that dominates Europe and North America driven by politics of progressive neoliberalism reinforces existing hierarchies and the hegemonic power structures of Western institutions, rather than democratising knowledge on a global scale. Although more radical scholar-driven OA initiatives emerged such as AmeliCA and Redalyc from the Global South, these efforts are often overshadowed by the commercial-oriented OA models that dominate the discourse and practice in the Global North (Chan *et al.*, 2019; Knöchelmann, 2021). A new "knowledge industry," as Fecher and Friesike (2014) have called it, is slowly but surely emerging from implementing Open Science. Fernández-Pinto (2020, p. 6) affirms that "The question arises whether Open Science is properly aligned with the values of transparency, democracy, and accountability that the movement fiercely promotes, or if it ends up compromising such value". In *"Breaking Ranks"* Diver (2022) critiques a point emphasised by von Schomberg regarding the prevailing irrational competition among universities to excel in terms of publication counts and venues, a trend evident in numerous university rankings.

He advocates for a re-evaluation of the role of rankings and suggests alternative approaches such as placing greater emphasis on qualitative assessments, community involvement, and adopting a more comprehensive perspective on academic excellence. Radder (2010) raised the questions: Can regulation mitigate the drawbacks of commodification? What alternatives exist to commodified science?

In addition to this discourse, the uncertain yet substantial impact of Artificial Intelligence (AI) on Open Access and Open Science must be considered, as it profoundly influences transparency, openness, and reproducibility – core characteristics of Open Science as well as responsiveness and responsibility (Buhmann & Fieseler, 2021; Santoni & Mecacci, 2021; Herrmann, 2023). Smuha (2021) has pointed at a race to AI that has engulfed many countries and regions and, therefore, has led to yet another race to regulate AI. Nevertheless, the development of the concept of Responsible AI (Agarwal & Mishra, 2021; Herrmann, 2023) supported the idea of AI for social good, emphasising on five ethical principles of "beneficence, nonmaleficence, justice, autonomy, and explicability" regarding the use of AI; and proposed that AI research initiatives be examined in respect to seven factors to determine if they are good for the society. These factors include "falsifiability and incremental deployment, safeguards against the manipulation of predictors, receiver-contextualized intervention, receiver contextualised explanation and transparent purposes, privacy protection and data subject consent, situational fairness, and human-friendly semanticisation" (Fioridi, 2020, p. 1773).

In sum, the examination of the science crisis indicates that systemic failures extend beyond the productivity and reproducibility issues highlighted by von Schomberg (2024). Extensive literature on these failures suggests the existence of a serious ethical crisis, demanding a deeper discussion on values and responsibility. And the pivotal question, "Does the adoption of open science principles require a fundamental shift in research cultures?" gains particular significance.

2. A MORE NUANCED AND CRITICAL APPROACH IN THE CONCEPTUALIZATION OF OPEN SCIENCE

The analysis conducted by von Schomberg clearly articulates the expected benefits of Open Science[4], including enhancing credibility, improving reliability, increasing efficiency, and meeting societal demands. It is an optimistic discourse that embraces a broad and "aseptic" definition of Open Science as "the early sharing of knowledge and data in open collaboration with relevant stakeholders" (von Schomberg, 2019; Burgelman *et al.*, 2019). But today, "the republic of science is hardly but a number of independent nations, all waving their own flag" (Hasselberg, 2012, p. 46). There is much hope in Open Science as a call for that inclusive collaboration of multiple actors, exempt from interactions of power and hierarchies. In the same way, Stracke (2020) maintains that "Open Science can help overcome the post-truth era by increasing the objective and subjective credibility of science and research, and "can serve as radical solutions to address issues of diversity, equity, and quality in research".

First of all, it is necessary to establish a clear distinction between OS and Open Access (OA), which is placed "at the core of a distributed communication system among producers of knowledge" (Guédon, 2017, p.3). As von Schomberg (2024) points out, this is a common misconception of OS by editors, universities and even research policies. It is essential to critically examine this distinction and its implications. While OA is a fundamental step towards democratizing knowledge and promoting inclusivity in academia, it's only one aspect of the broader concept of OS. Merely providing access to research outputs does not necessarily ensure meaningful engagement with scientific processes or foster collaboration among researchers and the public (Chan *et al.*, 2019; Knöchelmann, 2021; Dominik *et al.*, 2022). Moreover, a narrow focus on OA to published papers may overlook other dimensions of openness, such as open

[4] A more restrictive definition of OS comes from the UNESCO's Recommendation on Open Science as "an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community".

data, open methodology, and open peer review, which are equally important for promoting transparency and reproducibility in research. According to Bostrom (2018) openness in Artificial Intelligence can take different forms with different strategic implications, as the term can refer to open research, open-source code, open data, or to openness about safety techniques, capabilities, and organisational goals, or to a non-proprietary development regime generally. Ignoring these aspects could limit the transformative potential of OS in addressing systemic issues like research reproducibility, data sharing, and equitable participation in scientific inquiry. Guédon (2017) states that "while Open Access is now here to stay, it also displays a variety of forms that do not all conform with the project of distributed human intelligence with which it is associated. Lesser and degraded forms of OA have also and gradually emerged, sometimes as the result of power plays by powerful actors, sometimes out of compromises proposed by people of good will. At the same time, the very multiplicity of social actors now involved in Open Access has made the field much more complex than it was fifteen years ago", and adds "Meanwhile, digital culture is progressing apace, and its effects are profound, not just technological" (Guédon, 2017, p. 2)

In the debate on openness and mutual responsiveness it is necessary to take into account the diversity of movements, perspectives and practices that amalgamate multiple tensions on Open Science (Vicente-Saez & Martinez-Fuentes, 2018; Marco-Cuenca *et al.*, 2021; Hosseini *et al.*, 2022). In words of Fecher and Friesike (2014, p. 7) Open Science "is an umbrella term encompassing a multitude of assumptions about the future of knowledge creation and dissemination". In a broad and detailed bibliographic review, they identified five Open Science schools of thought: The infrastructure school (which is concerned with the technological architecture), the public school (which is concerned with the accessibility of knowledge creation), the measurement school (which is concerned with alternative impact measurement), the democratic school (which is concerned with access to knowledge) and the pragmatic school (which is concerned with collaborative research). More recently, a systematic review of Vicente-Saez and Martinez-Fuentes (2018) describes four orientations of open science: "transparent knowledge", "accessible knowledge", "shared knowledge", and "collaborative-develop knowledge", defining OS as "transparent and accessible knowledge that is shared and developed through collaborative networks".

Von Schomberg (2024) affirms that he prefers to talk about 'open research and scholarship', which explicitly clarifies the inclusion of the social sciences and humanities, and mentions the consistent use of the term in policy circles. In this respect, research literature highlights the increased divisions and disciplinary fragmentation not only in the so-called "three cultures" – sciences, social sciences and humanities – but also within each of them (Kagan, 2009; Sidler, 2014). Sub-disciplinary divides across the "three cultures" persist as well, creating pockets, or 'silos' of knowledge and epistemic communities with their own methods, languages, professional organisations, identities, and ethos. Kagan argues that the privileging of the sciences "created status differentials that eroded collegiality and provoked defensive strategies by the two less advantaged cultures" (2009, p. ix). In words of Sidler (2014, p. 83) "Either the movement will have to create and foster a broader definition of 'science' or it will have to replace the term altogether. To use the moniker effectively, the Open Science movement will have to acknowledge and address disciplinary divisions and monetary reward systems that led to this acrimony".

Additionally, it is worth highlighting the role of citizen science[5] (Hecker *et al.*, 2018: ECSA, 2024) and other challenge-incumbents that come from 'undone science' in areas of scientific research that remain incomplete or marginalised due to social, political, or economic factors from mainstream scientific agendas[6] (Hess, 2015, 2016). Overall, 'Undo-

[5] https://citizenscienceglobal.org/

[6] Hess (2015) argues that social movements play a critical role in challenge dominant paradigms, and advocate for alternative forms of knowledge production. He proposes a typology of "undone science" based on the nature of the scientific controversy and the role of social movements: 'Constrained Science' (research limited by external constraints), 'Oppositional Science' (research opposed by powerful interests), 'Counter-hegemonic Science' (research challenging dominant ideologies), and 'Participatory Science' (research involving collaboration with affected communities).

ne Science' offers a nuanced analysis of the complex interplay between science, society, and politics, bringing to the fore the potential of grassroots activism and public mobilisation to shape scientific knowledge and influence industrial transitions (Hess, 2016). Likewise, Stracke (2020) describes three general challenges for practising Open Science: the restrictions on flexibility, the costs of (additional) time required for Open Science, and the lack of an incentive structure. Although researchers serve as both producers and consumers of knowledge, Guédon (2017, p. 26) highlights that in the context of Open Science development "it is a strange paradox that a long – probably too long – discussion of the science communication system should end with the observation that researchers' role in the scientific communication process may well be quite marginal". These aspects need to be considered in a reflection on openness and mutual responsiveness alongside the practices and challenges of research integrity within the context of OS.

Knowledge production is not a monolithic process but varies significantly across fields, disciplines, and research communities, as well as the other actors from the Quadruple Helix (Chan *et al.*, 2019; Knorr-Cetina, 2013). Given the diverse array of movements, perspectives, and constellations of practices within Open Science (Field, 2022), how can we navigate the tensions and complexities inherent in promoting openness and mutual responsiveness across various disciplinary and institutional contexts? What strategies can be employed to address the disciplinary divisions and silos within academia, particularly between the sciences, social sciences, and humanities, in order to foster a more integrated and collaborative approach to research and scholarship under the umbrella of Open Research and Scholarship?

3. THE LIMITATION OF THE MERTONIAN FRAMEWORK AND THE SELECTIVE ANALYSIS OF VALUES

While the text revisits Merton's early contributions and the CUDOS norms, it tends to oversimplify the interpretation of Merton's ethos of science and there is no strong rationale for excluding the other principles. In an era emphasising diversity and inclusion, Universalism related to OS practices can help counteract biases and promote equity in scientific evaluation. Disinterestedness and Organized Skepticism can assist individual scientists in prioritising ethical considerations and upholding the credibility and reliability of science. These principles are essential in combating misinformation, as they emphasise the rigorous evaluation and critical analysis of research facing the 'dark side of competition' in science (Anderson *et al.*, 2007, p. 438). Moreover, Merton's concept of communism is depicted as closely related to the norms of openness and responsiveness. However, Merton's communism primarily emphasises the communal nature of scientific knowledge production and the imperative of sharing findings rather than individual adherence to open practices. This oversimplification may lead to a misunderstanding of Merton's original intentions.

On the other hand, the paper argues for broader governance of the institution of science in its relationship with society at large, questioning the efficacy of relying solely on self-governance within the scientific community. While broader governance is indeed important, dismissing the potential role of a new ethos of science overlooks the significance of fostering cultural shifts within the scientific community itself. An analysis of "openness" should consider in more detail the diversity of 'epistemic cultures' which refers to the diverse ways in which knowledge is created, validated, and circulated within different social, cultural and institutional contexts.

In recent years, there has been a wealth of research exploring the changing normative and practical framework guiding scientists' activities, presenting new interpretations of Merton's normative principles (Kalleberg, 2007; Macfarlane & Cheng, 2008; Lam, 2010; Koning *et al.*, 2017; Kim & Kim, 2018). For example, Macfarlane and Cheng (2008) identified an alternative set of contemporary academic norms, opposed to Merton's, which include capitalism, particularism, and interest. Kim and Kim (2018) express their concern about the persistence of communalism regarding openly communicating research results in the face of increasing academic commercialisation.

The scientific ethos stands as a dynamic social construct, mirroring the evolving currents of its surrounding context. Through the lens of structural and social perspectives on science, Konig *et al.* (2017) assert a tight interconnection between norms and values in contemporary scientific endeavours. These norms not only shape the conduct of science within specific contexts but, following Merton's framework, they manifest as prescriptive guidelines, enforced sanctions, and shared objectives. This combination gives rise to what is termed 'post-normal science', where the primary focus shifts from mere knowledge production to generating robust sociotechnical insights that facilitate decision-making processes and goal achievement. While navigating the discourse surrounding evolving scientific norms, they propose that the Mertonian normative framework serves as a crucial reference point. However, amid the intricate fabric of contemporary scientific landscapes, marked by complexity, uncertainty, and a diversity of legitimate perspectives, normative ambivalence emerges as a significant characteristic. This ambivalence, as highlighted by Lam (2010) through her exploration of hybrid values, underscores the nuanced interplay between diverse norms and values, particularly evident in fields such as applied science and professional consultancy services. Specifically, the Merton framework has constraints in supporting the examination of openness and co-responsibility within a context of epistemic uncertainty (Hofmann, 2022). Or, as Fuller (2007) affirms, in contexts of power dynamics and epistemic justice ambiguity. Despite of the tendency to update the powerful Mertonian framework as a basis for an analysis of science, it is necessary to recognise that "the institutional and political context which produced the Mertonian values is no longer with us" (Hosseini *et al.*, 2022, p. 18) and its validity remains very limited. As Hosseini *et al.* (2022, p. 18) maintain "if new normative structures for science are to have any traction in reality, they have to look beyond nostalgia and, in view of aspirations and outcomes of Open Science Practices, suggest prescriptive appeal for today's science". How can the institutionalisation of openness and mutual responsiveness within scientific governance frameworks address the oversimplification of Merton's ethos of science and accommodate the diversity of epistemic cultures? Considering the evolving scientific landscape marked by complexity and uncertainty, what incentives can be established to promote Responsible Open Science practices?

4. CONTEMPORARY RESEARCHERS' DILEMMAS: WHY INSTITUTIONALISING OPENNESS AND RESPONSIVENESS IS NOT ENOUGH

The preceding analysis reveals a mix of discourses and practices around Open Access and Open Science, encompassing the regulatory, normative, and cultural-cognitive aspects of emerging institutionalisation processes. While there is consensus on the need to reform science, with numerous bottom-up initiatives worldwide (Chan *et al.*, 2019; UNESCO, 2023), the imperatives of rankings and the rhetoric of quality and reputation associated with large-scale initiatives in the Global North prevail. These initiatives receive the majority of investments and maintain the hegemonic order. In today's academic landscape, heavily influenced by market dynamics and performance metrics, the prevalent 'gold open access model' often undermines efforts to foster genuine adherence to Open Science principles (Hess, 2016; Chan & Gray, 2020; Knöchelmann, 2021). Reflecting on openness and responsiveness, alongside the imperative of ethical reform, inevitably raises researchers' dilemmas regarding research integrity, normative ambiguities, and academic survival.

On the one hand, the relevance of creating knowledge aligned with mission-oriented research and co-responsibility in addressing societal challenges and advancing the green, digital, and social transitions and RRI, as von Schomberg's paper highlights. On the other hand, the realm of social practices of research institutions and individual researchers is strongly influenced by market forces, hierarchical structures, and network mechanisms controlled by publishers, funders, and governments. This contributes to fostering competition and a culture of individualism and self-interest, which tests collaborative relationships between scientists and erodes norms such as transparency and openness (Anderson *et al.*, 2007b). Research integrity practices are significantly shaped and threatened by the incentive structures of publishers and funders (Edwards & Roy, 2017; Field, 2022; Labib *et al.*, 2023). These competitive pressures lead to ethical dilemmas, such as conflicts of interest, exploitation of junior researchers, and scientific misconduct.

Hence, the intended adherence to the values of openness and responsiveness transcends merely reforming incentives and is linked with Pierre Bourdieu's concept of 'illusio' commented by Knöchelmann (2021). Many researchers are complicit in the deeply ingrained, often unconscious belief in the value and importance of the academic game, navigating the ambivalence, ignoring the arbitrary nature of certain rules and stakes, accepting them as natural. By participating, they reinforce the legitimacy of these rules and stakes, even if they question specific outcomes or aspects of the game.

In this respect, Labib *et al.* (2023) mention three modes of governing research integrity: markets (using incentives), bureaucracies (establishing rules), and network processes (via commitment and agreements). They maintain that fostering research integrity requires a balanced combination of these governance modes, as each has its strengths and weaknesses. For instance, while the network mode is more collegial and collaborative, it tends to be slower and influenced by group dynamics compared to market and bureaucratic modes.

Therefore, openness and responsiveness should be considered in dialogue with the performative role of scientific communities and research cultures that, in turn, shape the construal of integrity and build responsible research systems and cultures (De Peuter and Conix, 2023; Field *et al.*, 2024). The institutionalisation of openness and responsiveness should be for 'all the gamers', and this demands careful thinking about the Global North, the Global South, and beyond. And ideally, sharing knowledge should be rooted in solidarity, not driven by taxes or rewards. As Joy (2020) forcefully puts it, this approach to openness involves "taking back from commercial publishers the full reins of the means of production of academic publishing and reinventing the academic press as a critical arm of both the research and teaching mission of the University" (Joy, 2020, p. 324). Considering the evolving scientific landscape marked by complexity and uncertainty, what kind of incentives can be established to promote Responsible Open Science practices?

5. CONCLUSION

The debate on self-governance within the scientific community is multifaceted and critical to the future of Responsible Research and Innovation. Von Schomberg (2024) asks the question: Should we prioritise self-governance through a set of prescribed norms for individual scientists, or should we focus on institutional values guiding the broader institution of science? But is today the consideration of self-governance enough? Likely not. The complexity of contemporary scientific practice and its impact on society necessitates a more comprehensive approach. Only by integrating responsiveness and responsibility in science, *from within* into dialogue with other knowledge producers in wider society, can we hope to foster a robust, inclusive and effective framework for co-responsible scientific governance.

Institutionalising openness and responsiveness hold great promise for advancing Open Responsible Science at the core of RRI, but it also faces substantial challenges. These challenges include aligning consensus across diverse epistemic cultures and communities of practice, searching for appropriate incentive structures, and ensuring that the adoption of Open Science principles goes beyond mere compliance to incorporate genuine ethical commitments. Above all, it is about changing and institutionalising practices that contribute to overcoming epistemic injustices by creating more inclusive research agendas and ensuring that diverse voices – including undone science and citizen science movements – are heard in the decision-making process. The insights and efforts of scholars hailing from the Global South are frequently disregarded or underestimated. This disregard is exemplified by the marginalisation reinforced by the prevalence of English-language journals and the focus on metrics like rankings and citations, which can skew research priorities towards topics deemed prestigious or suitable for high-impact publications. And marginalise relevant research that may not fit neatly into traditional academic evaluation frameworks.

Continued dialogue on these issues is crucial for developing robust, inclusive, and effective frameworks that underpin the broader governance of the institution of science in its relationship with society. This includes responsive research, which involves shifting towards open science and engaging with societal needs, and responsible research, anticipating socially desirable outcomes by integrating foresight and technology assessment into research missions (von Schomberg, 2024). Through such dialogue, we can better navigate the complexities of integrating openness and responsiveness into the fabric of scientific research and fostering a genuinely Responsible Open Science.

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Responsive Research and Scientific Autonomy

Commentary on "Towards a New Ethos of Science or a Reform of the Institution of Science? Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness" by René von Schomberg.

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Von Schomberg's call to place *mutual responsiveness* – which I understand as the ability of researchers and the research system as a whole to foster meaningful exchanges and learn from novel experiences, no matter where those originate – at the core of Open Science and related efforts to reform the scientific landscape is both timely and significant. Widespread sharing is not enough to guarantee responsible and inclusive research, nor are vague appeals to improve research culture, whatever it is that such culture may turn out to include (Leonelli, 2023). Rather, emphasis needs to be placed on the conditions under which sharing materials, methods and insights – and debating the goals and directions towards which these may be put to use – may improve research exchange, communication and scrutiny, resulting in scientific outputs that are both reliable and socially responsive. Hence von Schomberg's focus on the interplay between institutional and behavioural features of science and his plea for a reform in governance structures, such as initiated by COARA, are very well-taken. He is, however, too quick to dismiss the importance of some degree of autonomy for those involved in creating knowledge. To show why this matters, I here briefly discuss two of von Schomberg's additional claims: (1) his focus on 'knowledge actors' as the protagonists of research efforts; and (2) his critique of the effectiveness of self-governance efforts by researchers.

Von Schomberg notes the importance of decisions around who should be considered as a *bona fide* 'knowledge actor', since it is those actors, in his view, that embody and enact mutual responsiveness. How does one demarcate such actors from misinformed, unskilled and/or partisan groups is a fraught question at a time when disinformation and echo-chambers, augmented by technologically mediated forms of pervasive communication such as social media, risk obliterating the difference between reliable and unreliable knowledge. This concern is exasperated by the immense fragmentation characterising the scientific community, which is arguably not one community at all – contrary to von Schomberg's formulation – but a vast ecosystem of diverse groups whose features are finely tuned to specific situations, goals and environments, including various constellations of collaboration with non-scientists (such as, for instance, farming communities in the case of agricultural science, social and medical services in the case of biomedical research, amateur birdwatchers in the case of ornithology and scuba-diving *aficionados* in the case of marine biology). As von Schomberg points out, there are ways to counter malicious attacks on the methods and legitimacy of scientific inquiry while at the same time preserving the non-dogmatic, critical character of scientific debate. These involve opening up research to contributors with relevant expertise from all domains and paths of life, thereby embracing the complexity of the research landscape and its multiple relations of transdisciplinary cooperation and dependence. This is the social space within which mutual responsiveness becomes both meaningful and hard to achieve, particularly given the interventions of individuals, groups and institutions who endorse the values and behaviour of knowledge actors in principle, and yet in practice use their understanding of the research process primarily as an instrument of control and dominance over others.

The platform economy associated with the emergence of generative AI and social media provides an ideal market for such take-overs: given the enormous investments, skills and resources needed to be a player in the development of AI-centred innovation, this is by definition an unequal space where even academics – those paid to conduct research in a professional capacity within higher education institutions – are at a strong disadvantage vis-à-vis the wealthiest private companies. Responding to concerns around power inequities in the conduct of research, philosopher Helen Longino (2002) has offered a modified set of norms for scholarly interactions, three of which are particularly useful for my purpose here: the development of opportunities and incentives towards uptake of criticism, where those engaged in research are regularly encouraged to consider constructive and evidence-based feedback; the existence of public standards by which the quality of knowledge can be evaluated, and which themselves are subject to frequent scrutiny to ensure their relevance and adequacy over time; and the cultivation of "tempered equality of intellectual authority", according to which anybody who has relevant expertise is welcome to participate in intellectual debate, yet choices are made around which voices should be highlighted and which voices should be toned down to avoid science replicating power dynamics already entrenched in society at large. While anybody with relevant expertise could be considered as a knowledge actor, this does not provide automatic legitimacy, and deliberation still needs to occur over which contributions are more or less significant and credible.

This takes me to a point of debate. I agree with von Schomberg on the crucial importance of institutional governance precisely to foster such deliberation, thereby fostering Longino's tempered equality. He, however, couples this argument with a vote of no confidence in self-regulating efforts by the scientific community, which he deems largely ineffective and grounded on an ideal of scientific autonomy which no longer holds. He takes the case of COVID-19 data-sharing efforts as a key example where cooperation was largely mandated and facilitated by scientific institutions rather than by researchers themselves, and autonomy played no role in researchers' decisions around what to share and when. I take issue with this interpretation of what the history of science teaches us in three respects.

First, the implementation of Open Science towards the pandemic response, despite strong incentives to share data and methods from countries around the world, has been neither homogeneous nor uncontroversial; more than one interpretation of openness has informed the development of platforms used to research COVID-19, resulting in ongoing debate over which forms of cooperation worked best for which purpose, and whether and how data sharing should be institutionalised in order to facilitate inclusive exchange as well as actionable outputs (Sheehan *et al.*, 2024). Within this fraught landscape, the decision to share research insights was often taken by individual researchers with a strong personal commitment to help address the global emergency through transnational collaboration.

Second, such personal commitment to open exchange is part of an ethos cultivated through decades – sometimes centuries – of research practice in domains such as astronomy, meteorology and natural history, which may not have been codified and represented in recent work by science academies, but recurs in the daily work of researchers around the world, as I have often witnessed in my own studies of scientific labour. Such a long history of openness is precious precisely because it fostered effective methods to establish and maintain meaningful relations with contributors, critics and stakeholders, thereby enhancing the responsiveness of science to social and technical challenges, inputs and critiques.

Third, as research becomes ever more technical and hyperspecialised, it is crucial to recognise the extent to which individual contributors – whether or not they are professional scientists – are called to take meaningful and responsible decisions on what to pursue, how, with whom, and for which purposes. In this sense, autonomy remains a necessary feature of scientific research, insofar as only expert contributors are in a position to translate abstract norms, policies and codes of conduct into practical methods and infrastructures suited to their specific situation of inquiry. Incentives, encouragement and adequate training certainly need to be in place for researchers to make such decisions – a critical point, I agree with von Schomberg, especially given the very limited acknowledgement of the labour and expertise required for such work within current reward systems in academia and beyond.

Yet the right governance and institutional settings can only go so far, with researchers needing training and incentives to play an active role in decision-making – thereby exercising autonomy in ways that may make research more or less socially responsive. This applies especially to the 'engineering perspective' that von Schomberg applauds within contemporary life science, which is centred on intervention but does not necessarily engage with questions of social accountability in a consistent or effective manner. Indeed, it could be argued that concerns with the ethical implications of engineering life, so prominent in the aftermath of the Human Genome Project in the early 2000s, have become peripheral to STEM activities and training in many parts of the world – a worrying development given the impact of bioengineering on every aspect of life on the planet, and one that we risk to see replicated in emerging forms of data science and generative Artificial Intelligence.

In conclusion, recognising researchers' agency and autonomy in making research responsive is critical to reforming scientific institutions going forward. The elephant in the room continues to be private and public entities, ranging from national governments to corporate industry, whose allegiance to political ideology and economic growth clashes with the norms, processes and outputs of science, while also conditioning almost every aspect of research, including how, when, where and why scientists get to circulate and scrutinise each other's practices and outputs. What institutions need to do is carve the right incentives, pedagogies and venues for researchers to retain the autonomy required to create meaningful collaborations with relevant parts of civil society under conditions of temperate equality.

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Intricacies in Steering the Direction of Science

Commentary on "Towards a New Ethos of Science or a Reform of the Institution of Science? Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness" by René von Schomberg.

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INTRODUCTION

René von Schomberg's article (von Schomberg, 2024) makes an invigorating case for the co-responsibility of societal actors to give direction to the pursuit of science. In this reply, I wish to endorse his position as a much-needed reconceptualisation in the face of societal challenges and internal scientific developments. At the same time, I urge that there remain theoretical and practical intricacies in attempting to steer science.

At the core of von Schomberg's analysis is the call for stronger integration of science into society. Instead of self-governance along the lines of a new scientific ethos, he advocates reforming the institution of science. In particular, he understands the institutional purpose of science in terms of addressing societal challenges; he calls for co-responsible governance of science along with other societal actors; and he proposes to reform scientific incentive schemes to reward collaborative behaviour (including non-scientists).

The call for better integration must be understood against a background of urgency related to contemporary societal crises – environmental, health, inequality, and power competition – and the assessment that the inherited system of science is unfit because it is too insensitive to address societal needs. The better integration of science within society has been on the agenda in Europe for many decades. One key step was *the Responsible Research and Innovation* discourse, which stressed that "societal actors and innovators become mutually responsive to each other" (von Schomberg 2013, p. 63). The most recent step in this development is Europe's shift towards "mission-oriented innovation policy" (Mazzucato, 2018). The idea of missions has conquered the imagination of policy circles because it suggests a way how different functional systems – politics, economy, science – play their role not merely by providing some abstract "public good", but rather as complementary contributors to a joint societal endeavour.

But the call reflects not only societal expectations, but also developments internal to science. Von Schomberg's call for better integration is not limited to societal necessity, but rather starts from a traditional — Mertonian — scientific norm ("communism"); this norm belongs to an ethos previously associated with the purity of science, at least by Merton himself. Yet today we see science not just as an unstructured process of knowledge accumulation, but emphasise its structural and normative properties that warrant ascribing it a "direction". A scaffolding of science-society interfaces (e.g. funding bodies) is already in place to shape such a direction. The question of the right direction is unavoidable and requires engaging with normative questions that go beyond merely functional requirements of science. Hence, the direction of research is a concern for all scientific stakeholders, not just scientists.

Despite my agreement, I sketch three intricacies by drawing on the work of foundational (yet perhaps unfashionable) theorists who have worried about outside interference with science. My comments revolve around the institutional function of science, the difficulties of steering, as well as the question of the constellation of co-responsible societal actors.

THE INSTITUTIONAL FUNCTION OF SCIENCE

Von Schomberg follows a recent wave of rethinking the function of science away from traditional knowledge production towards research missions addressing societal challenges. This places von Schomberg's vision squarely within the instrumentalist tradition of understanding the contribution of scientific organisations to society: their value should be seen in their contributions to the political or economic goals of the day. In previous decades, notions like the "entrepreneurial university" have emphasised the role of science for economic purposes, and more recently, the framing of societal challenges has brought a "revised social contract" between science and society (Martin, 2012).

By contrast, idealist views resist this identification of the function of science with political or economic goals, and instead emphasise the value of knowledge and understanding as such (Fuchs *et al.*, 2023). Merton, too, falls in this category: "Science must not suffer itself to become the handmaiden of theology or economy or state" (Merton, 1938, p. 328). He warns that if the value of science lies in "consonance with religious doctrines or economic utility or political appropriateness" (*ibid.*), then its acceptance will also be conditional on meeting these criteria. Wilhelm von Humboldt, the towering figure in this tradition, warned that the state must "not make use of its academy as a technical or scientific committee", but must instead "nurse the inner conviction that when they achieve their final [*scientific*] purpose, they will also fulfil its [*the state's*] purposes" (Humboldt 1810/2019, p. 4). It should be noted that such idealist views about the function of science need not necessitate strong views on its autonomy. Humboldt, for instance, thought that professorial appointments are too important and should therefore be reserved to the state. What matters is not autonomy, but instead that the guiding scientific ethos ("internal organisation") is oriented towards the pursuit of knowledge.

One approach to resolving this tension would be to draw distinctions between parts of science that are oriented towards certain societal goals, and those that are allowed a more idealist function. This could be done in terms of technical *vs* general universities, applied *vs* pure science, or engineering *vs* theory-led sciences. The former would then be delivering more transactional research for societal missions (along with a corresponding system of public justification, research evaluation and incentive schemes); while the function of the latter is seen in terms of society's culture, education and long-term enlightenment.

One danger with such distinctions is that those parts of the scientific system that are unable to justify their existence in terms of research missions will lose funding, talent and interest. The social sciences and particularly the humanities are likely to suffer and would at best legitimate their pursuit through some roundabout constructions framed in instrumentalist terms. But this would fail to give credit to their potential in enabling new understandings, concepts and avenues of action, which we may be unable to envision now. Besides, scientific organisations play important reflective functions, both for politics and society. Normative reflection and societal critique must go deeper than being merely a companying voice in missions. Societal challenges and missions are not the end of history. Human society continues to evolve in fundamental ways including our priorities and understanding of our problems. A continued commitment to social sciences and humanities may be a crucial reservoir of ideas and disruptions for this evolution. Furthermore, a confident and operationally self-standing scientific culture will also be a greater inheritance to future generations than one limited to thinking about the political or economic goals of the day. This is at least one reason why such traditional distinctions in public justification and evaluation of science should be avoided.

Another approach would be to formulate another type of long-term research missions that are designed to stimulate deeper human understanding as such, and thus especially the social sciences and humanities. Instead of the Apollo programme ("putting a man on the Moon"), these missions would take inspiration from historical examples like the *Encyclopédie* produced in 18th Century Enlightenment France ("surveying all of human knowledge"). In line with von Schomberg's proposal, these missions could be co-created and implemented with non-scientific actors; research behaviour engaging with stakeholders could similarly be incentivised. While these missions would face their distinct problems – most importantly, the multitude of theoretical, epistemic and methodological approaches makes it difficult to think of complementary actions within missions – they would similarly integrate science into society, while re-invigorating the pursuit of "traditional" knowledge-oriented enquiry.

THE DIFFICULTY OF STEERING SCIENCE

Von Schomberg rightly points out the lack of a "demarcation criterion" between scientists and ordinary citizens engaging in truth-claims. This gives additional support to the idea that shaping the direction of science must be opened up to include non-scientists. Everyone engaging in science – even citizens – must be involved in shaping and conducting science. Yet we can doubt whether this framing gets to the heart of the difficulty of steering science. Instead of asking which people should have a place at the table shaping science, we should ask which types of reasons, communications or social systems should be given such a role. Should politics steer science?

If we view society as consisting of different functional subsystems, such as politics, economy, law, science, education or morality, we can start to conceptualise both the need for greater integration among these, as well as the challenges in doing so. The German sociologist and systems theorist, Niklas Luhmann, famously argued that modern society is increasingly characterised by the operative closure of these functional subsystems, a process which he calls “functional differentiation”. The more one of these subsystems becomes differentiated, the greater the tension with the others. Society seems to drift apart, given these mutually unintelligible forms of communication.

The scientific system, among others, could develop its quality and complexity not through being addressed towards the goals of other subsystems, but rather through the decoupling of its dynamic from the conditions and interests of its environment (Luhmann, 1990). Similar remarks can be made about the differentiation of other subsystems in society, such as the economy. For Luhmann, the implications of such a systems-theoretical view on science is that the structures of the science system cannot be determined by outside forces. Of course, other systems, such as politics, may intervene or shape and urge the scientific system. Yet for the scientific system, these will remain irritations which it can, at best, re-interpret in its own terms. Politics and other subsystems can suggest topics and research directions and agendas, but – Luhmann contends – in this way “no concepts are yet developed, or research results developed” (*ibid.,* p. 639). The persistent pressure of politics to deal with certain scientific topics may have the effect that the scientific systems ends up making promises to deliver scientific insights (“truths”), without being able to guarantee their delivery. We may observe this type of inflation of promises when grant proposals list lavishly the sustainable development goals that the proposed research will contribute towards.

In light of the persistent dominance of academic disciplines, journal prestige, and citation metrics – in other words, key determinants of academic behaviour that may at least sometimes be obstacles to open science –, the call to co-shape the direction of scientific research with other stakeholders may remain too weak. The call to incentivise scientific behaviour that reflects openness and mutual responsiveness may be insufficient to challenge established practices and may be treated as mere irritation to scientific practice.

Such an incentive scheme would ideally be accompanied by arguments about why such collaborations are likely to generate novel scientific insights; in other words, appeals to norms and goals internal to science.

CO-RESPONSIBILITY WITH WHOM?

Besides the question about the societal function of science and the difficulties of shaping its direction, we should also be attentive to the interests and particular constellations of actors aiming to shape science. Not all constellations of co-responsible societal stakeholders will advance science or address society's needs. Even if we assume that directing science is possible in principle, we must be ready to prevent science from being captured by special interests or authoritarian political agendas.

In the last decades, and particularly in the US, the strong identification of science with economic growth also provoked criticism of the subjugation of science under such goals. The literature on "academic capitalism" (Slaughter & Rhoades, 2004) points to the influence of businesses and economic interests in shaping research agendas, educational curricula and fostering secrecy around research results, as well as potential conflicts between academic and economic interests. This dominance of economic goals within science was cemented rather than challenged by a system of public research funding that allowed the commodification of research findings (Mirowski, 2011) and local communities or civil society assuaged by the promise of regional development.

One way of avoiding such dominance of certain interests would be to insist on the fair distribution of costs and benefits in such constellations of co-responsible societal stakeholders. It is unfair for one group of actors to fit the bill or to do the work, while others take away the profits. However, more is at stake than merely the problem of whether scientific organisation (or the public sector) receive their fair material share of collaboration. This returns us to the reflective function science plays within society.

Science that is open to being steered by social collaboration will depend in its external legitimacy, self-understanding and funding on such collaborations. The danger is that the delicate balance of collaborations with politics, economy and civil society may fluctuate. Authoritarian political forces would welcome a scientific system thus dependent. Some industries employ a large shadow of the scientific system (for example, the food industry) that is aimed at capturing or undermining scientific credibility.

Science that is integrated more fully into society is likely to be more directly impacted when power imbalances or overreach by one functional subsystem deviate from a more idealised picture of co-responsible societal stakeholders steering science. It is therefore imperative that scientific organisations have a clear and confident view of the societal function of science, also beyond serving immediate political or economic goals.

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Towards the Non-Mertonian Ethos of a Non-Mertonian Science: Situating the Research Value of Openness

Commentary on "Towards a New Ethos of Science or a Reform of the Institution of Science? Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness" by René von Schomberg.

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It is hard to disagree with the thrust of René von Schomberg's position paper. It is driven by the worry that current conceptions of "open science" are all too impoverished – that they need to be complemented by the social practice of "mutual responsiveness". Whether in terms of political theory and notions of democracy, or in terms of socially relevant research practice – only an ambitious commitment to open science will be robust enough to make a difference and contribute to research that addresses global challenges. In contrast, it is paying lip service only to the ideal of openness when "open science" is reduced to "open access publishing" or data storage rituals. As von Schomberg shows, this might actually deepen disparities and redundancies within dysfunctional science.

And yet, the particulars of his argument fail to effectively make the case. Von Schomberg calls on two prime witnesses to testify to "open science": There is the historical antecedent, perhaps a voice of conscience, personified by Robert K. Merton and his idea of "communism" or public ownership as a norm which is held to binding for the scientific community. And then there is the recent history of Covid-19 research where scientists surrendered personal ambition and the quest for originality and readily shared data to support public problem-solving. Neither of these precedents, however, points towards von Schomberg's ideal of open science, and together they produce an incongruous picture of science that obscures rather than highlights the questions at hand.

ROBERT K. MERTON

In the face of Nazism and Stalinism, at the time of "German physics" and "Lysenkoism", the Weberian sociologist Robert Merton revisited "Science as a Vocation" and articulated "that affectively toned complex of values and norms which is held to be binding on the man of science" (Merton, 1973, 268-269; compare Weber, 1946). This can be viewed in the context of a research program which takes as its starting point what Merton has called the Thomas theorem: *If people define situations as real, they are real in their consequences* (Merton, 1973, p. 262). What scientists hold themselves to be bound by is constitutive of "science" as a social institution. Irrespective of the many violations of these values and norms, they serve as regulatory ideas, provide orientation, occasion ambivalence or even a guilty conscience and thus retain their effective normative force. Why do scientists hold themselves to be bound by just these norms? Merton does not address this question. As von Schomberg notes, he presupposes the commonplace answer of the day which can be traced back to Immanuel Kant and the Kantian tradition in 19th and 20th century physics and philosophy: To advance "Enlightenment", the “disenchantment of the world”, or the “extension of certified public knowledge”, what is required is a public sphere that is defined by the absence of traditional authority and parochial interests. One enters the public sphere as one enters a game, and the rules of the games bind the players to discursive norms. The republic of scholars or scientific community is the model of such a game where one can win only by having the better argument, where knowledge is freely shared (communism), where all reasoners are equal (universalism), where personal ambition, ideological tenets, questions of relevance and practical benefit are bracketed (disinterestedness), and where everyone is committed to the give and take of argumentation (organized skepticism). Is this game an idealisation of science? No. Is it a picture of what goes on in science? No. This is where the Thomas theorem comes in (Merton, 1973, p. 260-263). The mere game of science is defined as real and can therefore produce very real consequences. For the people who play this game, it is an indispensable part of scientific practice to finally publish a paper that renders a rather unprincipled messy process very tidily and according to the normative precepts of their profession – the extension of certified knowledge is presented as if it involved nothing but persuasive arguments regarding the evidence for and against theories or hypotheses. It is in this sense, famously, that every scientific publication lies (Medawar, 1996): It projects the labours of scientists into the sphere of the game, transforming hard-won experimental findings into objects of collective deliberation – as if there were no ulterior motives, powerful financiers, nasty competitions involved. For the people who play this game, there is no better way to achieve what they consider scientific knowledge.

To be sure, Merton’s argument can also be viewed also as his emphatic political commitment to science and Enlightenment – envisioning a specific interface between science and democracy. He was not alone in this, with similar arguments presented by Michael

Polanyi, Karl Popper, and others: The game of science served and sometimes still serves as a model for rational deliberation in the public sphere, it exemplifies what Jürgen Habermas considers the non-coercive force of the better argument (Habermas, 1984, 11). The intrinsic commitment of science to communicative rationality and democratic deliberation did not imply, however, that science should take notice of what is going on in that other public sphere of civic democracy, that it should be interested in the problems, concerns, priorities of citizens. Indeed, when one envisions science as part of civil society and subject to public reasoning, more broadly conceived, one is confronted with a very different interface between science and democracy. It takes a rather daring construction to conflate the two – and René von Schomberg is offering such a construction: Since Merton offers no demarcation criterion of science, he cannot exclude anyone from the sphere of scientific reasoning and therefore must admit all deliberators into the world of science, thus infusing the scientific community with civic sentiments and concerns (von Schomberg, 2024, 7). Indeed, according to Schomberg, Merton's commitment to openness requires just this.

This is a daring construction because it is not at all clear that any of this follows from Merton's failure to provide an explicit demarcation criterion or from the unavailability, in principle, of such a criterion. It is evident that Merton, following Max Weber, assumes that not everyone holds themselves to be bound by these certain values and norms, and certainly, that not everyone seeks to extend certified public knowledge. In this regard, science as a profession is like medicine or the law, institutionally constituted by a set of commitments and mechanisms of self-governance such as accreditation, peer-review, and the like.

To be sure, Schomberg is not the first who seeks to "improve" upon the Mertonian conception of science, extending the values of science towards the political democratization of science. Gernot Böhme, Wolfgang Krohn, Wolfgang van den Daele, and others formulated in the 1980s the so-called finalization thesis, suggesting that communicative rationality, the norms and methods of science require that scientists collectively deliberate the ends of science, including the choice of questions and problems (Schäfer, 1983). Science would be incomplete, they argued, if it stops short of openly debating the application of science and how it should serve societal interests. It would thus be a necessary next step of science to become political, that is, engaged with civil society. In the meantime, John Ziman, Michael Gibbons, Helga Nowotny, and others described a "new production of knowledge" that is responsive to societal interests (Ziman, 2000; Gibbons *et al.*, 1994). Having identified "originality and novelty" as a fifth norm to complement and complete the Mertonian conception, they proposed a dynamic that invites considerations of social needs, technical and economic interests.

Either way – whether we follow von Schomberg or the latter theorists of science – it is unhelpful to conflate openness as a value of science and openness of science towards society. Openness as a value of science negates authority and hierarchy as well as parochial "special" interests, openness of science towards society subjects it to (legitimate) considerations of relevance and interest. By conflating these notions of openness, one also conflates the game of science as extension of certified public knowledge with quite another game of using scientific theories and capacities to accomplish things of technical, practical, societal relevance. One thereby finally conflates the modern project of Enlightenment and a project which Ulrich Beck, Anthony Giddens, and Scott Lash discussed as second modernity, namely a project of repair that attempts to reflexively manage the ecological and social problems that arose through modernization (Beck *et al.*, 1996).

Indeed, the finalization theorists, John Ziman, Michael Gibbons and his collaborators did not suggest that the democratization of science and its openness towards society are consistent with Mertonian notions of communism, universalism, disinterestedness, and organized skepticism. On the contrary, the problem of "finalization" arises only once the game of science is over, that is, when the business of theory-development is "closed" and the problems shifts to the ends that can be served by all the already accumulated knowledge of science. John Ziman and the others explicitly associated the Mertonian norms with the peculiar institution of academic science or mode-1 research and spoke of the new production of knowledge as non-academic mode-2 research with its orientation towards social needs. Accordingly, the Mertonian norms are said to be displaced by a new social contract between science and society and a different view of the interface between science and democracy – not in terms of communicative rationality but in terms of public engagement and participation. This new social contract redefines public knowledge as intellectual property, introduces relevance, inclusion, responsibility as values that are held to be binding on scientists. Steven Shapin in his book on the scientific life in Silicon Valley provides "a moral history of a late-modern vocation" and adds familiarity and charisma as counter-norms to universalism and disinterestedness (Shapin, 2008).

Of course, René von Schomberg also laments that public knowledge is now conceived as intellectual property and therefore rediscovers Merton as a promoter of open science. At the same time, however, he does not and would not endorse the call to go "back to academic science". He does not appear to fully acknowledge that the values of Mertonian science simply are not made to provide orientation for post-academic "open science". And so, his attempt to apparently build on and widen Merton's Enlightenment conception of science ends up with a brute substitution of the very definition of "science": Merton's institution for the "extension of certified public knowledge" becomes Schomberg's institution for "societal challenge based knowledge generation": By speaking in an undifferentiated manner of "science", profound differences are obscured. It appears that the concept of the scientist independent of society is merely "rephrased" when the position is, in fact, to entirely replace it with the concept of the scientist as "knowledge co-producer in and with society" (von Schomberg, 2024, 23, 27).

COVID-19

The wilful conflation of academic and non-academic science makes sense, of course. As a participant-observer of changing science-and-society interactions, Schomberg welcomes the new social contract. He sees the tremendous gains towards an opening up of the research process in recent decades – but in terms of a Habermasian political philosophy he is also worried about the attendant losses. Non-academic technoscience has severed the bond of science and Enlightenment, it valorises innovation and loses sight of social progress. Can't we have our cake and eat it?

To be sure, we are fully in agreement that this is the challenge of the day – to secure the legacy and spirit of Enlightenment for the current age, also in the sphere of science and technoscience. But precisely because this is an important task, we are ill-served by Schomberg's conflation. This is especially evident when he cites Covid-19 research as a shining example of open and mutually responsive science. Schomberg's judgement is based on the conduct of researchers who did not seek personal gain but diligently provided data for public management of the pandemic. Fair enough. This they did, though the data in question were collected primarily by public health agencies that have cultivated the art of epidemiological data collection for at least 100 years. Aside from using different tools to visualise the data curves, their method of generation hasn't changed much in all this time. And even older is the art of treating epidemics by isolating potential carriers of an infectious agent.

Quite apart from this and in a highly competitive entrepreneurial spirit, vaccines were developed with all the redundancies and duplications of effort that one typically sees in such competitions – when everyone has a sense of how it might done, but one will be faster, perhaps better at it. If both, epidemiologists and vaccine developers, responded to societal needs, there were many others who stood by silently, failed to respond, or were not even asked to respond. On the one hand, there was aerosol science that never had its day, though it might have contributed innovative ways of moderating, filtering, streaming the flow of infectious droplets, thus complementing the wearing of masks. On the other hand, there were the social scientists, including STS scholars, who stood by and watched the utter political disregard of their much-heralded knowledge society. Governance efforts did not seek to mobilize the distributed intelligence and experimental spirit of citizens, and yet the STS community hardly commented upon 21^{st} century governance in the style and manner of 19th century public health and population control. The best that can be said about the COVID-19 constellation of science, politics, and society is that it worked, and that scientists played along without rocking the boat – that the virtues of diligent data-management overshadowed the exercise of creativity and intelligence while everyone was waiting for the vaccine-to-come.

One would hope and expect that there are better examples of open and responsive science – this one was selected by von Schomberg because it looked like ordinary science minus some of its dysfunctionality. Instead, the models of open and responsive science might be sought in citizen science as it is practised in the context of patient-initiated clinics, of environmental advocacy, of science-diplomacy and peacebuilding. These paradigms of open or citizen science follow a public policy agenda, are committed to values such as social, economic, and ecological justice. They integrate scientific research methods within an agenda of political Enlightenment, fully aware that they do not carry on but contravene the values of academic science. Holding the Mertonian ideal of openness within self-governed science apart from the institutionally enforced mutual responsiveness in technoscience-society interactions, and bringing politics back in – this might be the more straightforward way to overcome impoverished notions of "open science".

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Responses to the critics

Personal comment on the responses to "Towards a New Ethos of Science or a Reform of the Institution of Science? Merton Revisited and the Prospects of Institutionalizing the Research Values of Openness and Mutual Responsiveness" by René von Schomberg.

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Carl Mitcham, unlike any other author, has established a comprehensive philosophy of engineering. He has made philosophy relevant for engineers and engineering relevant for philosophers. We agree that engineering should be distinguished from the sciences. The sciences and engineering have evolved asynchronously in terms of the governance of their communities and institutions. As Carl Mitcham rightly pointed out, the engineering field adopted codes of conduct emphasising responsibilities for public health and safety early on. In contrast, the sciences have consistently attempted to 'externalise' such responsibilities to civil and political bodies. Governing institutions for the sciences were established in the Western Hemisphere in the mid-19th century. However, the National Academy of Engineering in the USA was established only in 1964, and the Netherlands will inaugurate its own Academy in 2024. It is, therefore, not surprising that distinguishing the governance of the engineering community from the institutions for engineering is more complex than in the case of the sciences (with the exemption of state-controlled technology, e.g., for engineering, for the military, etc.). This disparity has long impacted higher education: In Europe, polytechnic institutions existed as separate institutions of higher education for engineers, positioned hierarchically in relation to universities. These institutions gradually merged with the university system from the 1990s onwards.

Ironically, fields within the traditional sciences are progressively evolving into areas of engineering, such as nanotechnology, bioinformatics, genetic engineering, and synthetic biology, which require distinct forms of governance. I thus welcome Carl Mitcham's extension of my table in the position paper. Mitcham warns against overly grand expectations for public participation. However, my argument is not about participation *per se*, but about orienting research missions and research policy toward socially desirable objectives. This does not necessitate direct public involvement but does require a high degree of openness and transparency within science and at the science-society interface, enabling research missions based on social collaborations with societal knowledge actors.

Mónica Edwards-Schachter raises pertinent issues regarding the commodification of scientific knowledge, the conceptualization of open science, and the selective focus on specific research values. I have argued elsewhere (von Schomberg, 2019) that while radical open science is essential, it is not sufficient for responsible research and innovation (RRI). RRI necessitates additional measures, such as the institutionalisation of anticipatory governance and value-driven innovation. The commodification of science is one of the factors that contributes to a closed, overly competitive form of science, rather than fostering progress through open collaboration. Edwards-Schachter extends my argument by providing valuable insights into the negative consequences of science's commodification.

Moreover, RRI must address market failures to enable the transformative changes required to meet the Sustainable

Development Goals (SDGs). This involves institutionalising value-driven innovation, a topic beyond the scope of our current discussion. While articulating the constitutional research value of 'openness' is necessary, it is only one, 'constitutional' research value. It is of course not the only value to effectively address the much broader issue of responsible innovation. I recognize that the Mertonian framework is inadequate for today's socio-political context and acknowledge the diverse epistemic cultures within the sciences (Sabina Leonelli also refers to this diversity). I specifically highlighted the engineering sciences because of their ambivalent attitude towards 'openness', but it may be necessary to examine other fields as well. However, this does neither affects the overall argument on governance of research missions nor the overall argument for managing research around research/scientific missions concerning societal challenges.

I also appreciate Edwards-Schachter's comments on the counterproductive ways it is implemented in current Open Access policies. The prevalent model of gold open access, where authors or their institutions pay for publication, undermines the essence of 'real' open science. It reinforces scientists' preoccupation with publishing and for higher citation rates rather than sharing knowledge and data prior to publication. Additionally, it motivates scientists to move to institutions with the most substantial budgets for this purpose, a perverse incentive creating inequities in the scientific system and among countries. This practice undermines the necessary resource-sharing among scientists to effectively preserve and constitute public goods.

I am pleased with ***Sabina Leonelli's*** response. She has significantly contributed to the field of open science (see Leonelli, 2023) both as an author and through her input in public policy. The apparent disagreement arising from her response is more about the details of how to implement open science rather than matters of principle. I based my argument on a radical concept of open science: 'open collaboration and knowledge sharing prior to publication', which virtually equates to "science done right". However, neither the self-governing scientific community nor the governing research institutions, such as research councils and funding organisations, wish to embrace this concept fully, let alone to take it as a basis for funding and rewarding research proposals.

The implementation of open science as a response to Covid 19, as it stands – partly voluntary, as Leonelli rightly pointed out – has been incomplete, debatable, and in some instances, probably even wrong. Nonetheless, even this imperfect approach was necessary to deliver vaccines within a short period. Business as usual would have taken a decade. We cannot rely on the voluntary and morally driven responses of an 'autonomous' scientific community as the default situation. My argument is to make the scientific community's responses independent of commendable moral initiatives by providing a different incentive system, primarily based on encouraging research behaviour irrespective of the normative assumptions scientists may hold. In the absence of such a system, I can only hope that even imperfect open science practices will address urgent societal challenges, though institutional reform of science should remain on the agenda.

Leonelli's second comment, which aims at guaranteeing the quality of scientific deliberation and the deliberation at the science-society interface, is partly addressed by her own observations. Leonelli rightly points out to the need for additional norms on top of 'openness' for deliberation, such as mechanisms to ensure the uptake of criticism (which then would 'institutionalise' mutual responsiveness). However, we cannot rely on the self-governance of the scientific community to facilitate this. For example, the statutes of the European Food Safety Authority require, in cases involving the precautionary principle, an active search by appointed experts to identify disagreements within the scientific community. They must not only 'weigh' the arguments but also engage in a debate. They may practice this principle imperfectly, but it shows that we need responsible governing institutions to ensure this deliberation and public scrutiny to check if they actually do. The 'autonomous' scientific community will certainly not do it.

We may also need to think of other mechanisms of quality assessment inspired among other by the work of Ravetz and Funtowicz (2015), a topic I dealt with already in Von Schomberg (2007, 1992). I agree with Leonelli that this is highly desirable.

Lukas Fuchs' thoughtful comments require me to be more precise about the nature of the missions. My preoccupation with providing 'directionality' to research and innovation may have given the impression that the governance of the scientific community should be entirely devoted to societal-challenge-based missions. I must acknowledge that addressing scientific challenges remains a crucial function of the scientific community. Nonetheless, these purely scientific challenges can also be governed through research missions with the identical incentives for research behaviour as research missions addressing societal challenges. (e.g. early knowledge sharing prior to publication and open collaboration). The radical open science rationale of open collaboration and early knowledge sharing is the foundation of successful, globally collaborative, networked (pure) science. The Nobel Prize-winning article that empirically confirmed Einstein's claim of the existence of gravitational waves was co-authored by 1,000 individuals. Open science requires the input of all relevant knowledge actors, although some missions can certainly rely solely on knowledge actors within the sciences.

The functional differentiation of science, politics, economy, and the legal system in complex societies, as thematised by Luhmann, should not be abandoned by blurring the distinction between politics and science. Politics should not 'steer' or politicise science; hence the proposal to establish co-responsibility for giving direction to science and innovation at specific science-society interfaces, such as research councils and technology assessment offices. This also applies to purely scientific research missions. The public funding of these missions also requires legitimation[1]. Purely scientific endeavours are hardly ever fully detached from societal challenges, as the European Research Council's funding of 'Frontier' science demonstrates. However, research funding and governance should not be reduced to merely serving the plurality of funding needs within the scientific community (e.g., fundamental research, societal challenge-based research, industrial research, etc.) but should also address the governance of the science system in terms of productivity, effective resource sharing, and delivering on socially desirable outcomes. The current funding of science undermines the productivity of the science system (for details, see von Schomberg, 2019).

The establishment of co-responsibility to govern both the institution of science (through science-society interfaces) and the community of science (through open collaboration among knowledge actors within science and society) cannot be equated with the politicisation of science. 'Openness', both as an institutional value of science and democracy, provides a procedural basis for directing science in a deliberative democracy. It should also guarantee full transparency of these interfaces.

This brings me to ***Alfred Nordmann's*** central claim that I conflate 'openness' within science with 'openness' in a democracy. This was not the basis of my argument. I must clarify that 'openness' in science serves the institutionalised process of cooperative truth-finding, while 'openness' in a democracy aims to optimise civic participation in social-political agenda-setting and decision-making. In both cases, openness is an institutional value that relies on incentivised scientific and civic virtues rather than enforcement or codes of conduct.

The institutionalised cooperative truth-finding in science does not imply

[1] My 'model' of research funding involves funding based on missions that are rooted in open collaboration, both within science and beyond academia, involving other knowledge actors. Employers of scientists should incentivise research behaviours that promote open collaboration and early knowledge/data sharing. The evaluation of researchers should be based on the quality of their contributions to these missions. However, this model cannot encompass all types of research. For instance, authors of monographs in the humanities may not fit into this framework.

that science produces Mertonian 'certified knowledge' or that it holds the exclusive authority to inform politics. I even argue that science does not have the sole authority to determine the goals of its own truth-finding process. For effective knowledge production in addressing societal challenges, we require consensual knowledge (as long as the consensus lasts) and consensual directionality in science and innovation. This can be achieved through social collaboration with knowledge actors both within and beyond academia and by strengthening the governance of science through science-society interfaces. This approach neither conflates nor undermines the cooperative truth-finding process, as long as we maintain the distinct institutional values of openness in both science and democracy.

Social collaboration with a variety of knowledge-actors is not identical to citizen science, although the outputs of citizen science should be included in broader deliberations on scientific findings within the science-society interface. I am puzzled by Alfred Nordmann's claim that "He does not appear to fully acknowledge that the values of Mertonian science simply are not made to provide orientation for post-academic 'open science'." I believe that this is a misreading of my text. The table I provided demonstrates that my position on both the normative structure and functions of the scientific community and the institution of science is a revision of the Mertonian position. It is not only a revision of Merton's value of openness but also the provision of a new governance framework fit for the contemporary situation.

My explanation of the emergence of an ever-dominating 'engineering perspective' in the sciences shows that issues of responsibility are becoming integrated into science, counter to the Mertonian norm of disinterestedness. Moreover, I aimed to demonstrate that Merton's original incentive for originality, combined with his norm of communism (openness to and communality of know-ledge sources), has lost its function. Radical open science requires virtually instant knowledge sharing prior to publication, thereby abandoning the priority for originality (and thus giving up on the possibility of 'original' publications) in favour of open collaboration. My position, therefore, differs from earlier attempts to revise Merton, such as those by Nowotny, who still hangs on to 'originality' and at the same time seeks to identify consensus of cooperative truth finding process across sections of society with the production of 'robust' knowledge. The latter would indeed conflate the science/society differentiation and even mix evaluative criteria for scientific truth-finding with empirical issues of consensus formation in society.

I disagree with Alfred Nordmann's diagnosis of the current situation. I claim, on one hand, that the traditional cooperative truth-finding process in science is corrupted by an overly competitive and closed system, and by issues such as the commodification of science. On the other hand, I argue that we required interventions from research policy to open up science to deliver on vaccines. The case of COVID-19 was not an ideal example of open science at work, but it was just enough to succeed once. Hence, my preoccupation is with further opening up science – COVID-19 was a small step, but we need to take several more.

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