



The Economic Logic of Open Science in Fusion Energy Research: a Systemic Approach to Policymaking

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1. Background and Rationale

Climate change is a grand challenge of our era. From an economic point of view, government intervention is justified to address two market failures: one environmental and one technological. The former results from an overprovision of electricity from fossil fuels, while the latter from an underprovision of research to develop greener technologies. Environmental technology policy must jointly address both market failures due to their interconnections (Jaffe et al., 2005). On the one hand, the standard approach to climate policy has been to limit the emission of greenhouse gases (GHG). On the other hand, the adoption of greener technologies can reduce or eliminate GHG emissions.

This paper focuses on the development of one of such greener technologies: nuclear fusion, which is the reaction that occurs within the stars, including the Sun, to generate their own energy. A technological breakthrough in nuclear fusion energy can help to decarbonize the power system because it can provide clean, safe, and affordable energy without the amount of nuclear waste resulting from fission reactions, which currently occur in fission power plants around the world. However, fusion energy research is still on the edge between science and technology because it still requires large investment in basic research before developing technological applications.

Despite the infantry stage of fusion energy research, this industry is experiencing a transition from publicly to privately funded research (Carayannis and Draper, 2021). The influx of private funds is changing the objectives of fusion energy research from an approach based on open science, where the scientific results are shared within the global fusion community, to an approach based on proprietary technologies, where each company protects its technological applications with Intellectual Property Rights (IPRs).

Whereas the enforcement of IPRs can create economic incentives for private companies to generate even more technological applications in the field of nuclear fusion and will eventually lead to the commercialization of fusion power plants, stricter IPRs are often associated with high social costs that result from restricting the access to the knowledge that was previously shared within the global fusion community and thus limit the effectiveness of nuclear fusion in climate-change mitigation policies.

2. Methodology

Building on the new Economics of Science (Dasgupta and David, 1994), this paper develops a systemic approach to science and innovation policy in fusion energy research as it transitions from public to private funding. The overall objective of this systemic approach to policymaking is to strike a productive balance between the publicly funded community of scientists, who tend to favor full disclosure of their results, and the community of privately funded technologists, who tend to favor disclosure only after receiving a patent. This productive balance between the two communities can be achieved when policies fund open science and check against excessive

incursions of claims to IPRs (David, 2003). To achieve this objective, the methodology employed by this paper is to interview key players in both communities to gather information on how they view open science in fusion energy research. Interviews allow to gather rich information on this topic and they are a qualitative research method that can be used as a foundation for future quantitative research on this topic. To the best of our knowledge, no other authors have outlined a systemic approach to policymaking in this industry. Despite its limitations, the qualitative method employed in this paper has the ability to assist policymakers who seek a regulatory framework to guide the future of this industry.

3. Anticipated Results

Some of these interviews have already been collected by Michel Claessens, who was the spokesperson from 2011 to 2016 for the International Thermonuclear Experimental Reactor (ITER) project, which is currently the largest publicly funded project in fusion energy research. These interviews provide preliminary evidence that scientists who are working in the ITER project follow Merton's (1973) norms of Communalism, Universalism, Disinterestedness, Originality, and Skepticism (CUDOS).

These preliminary results support a systemic approach to policymaking in fusion energy research that stresses the benefits of openness in science because all the intellectual property developed in the project is shared equally by all the global members of ITER.

Claessens (2020) also interviewed some of the private companies that are supplying equipment to ITER. These managers also confirmed that openness in science allows the communal, universal, and original approach required to supply hi-tech components that meet the stringent specifications of a first-of-a-kind project, such as ITER, whose consortia of suppliers span across the world.

4. Significance

Climate change is a complex problem that requires multiple solutions from multiple disciplines. Science and innovation policy in greener technologies can help to mitigate this complex problem by fostering the development and adoption of technologies that can reduce GHG emissions. Although not a panacea, nuclear fusion can provide clean, safe, and affordable energy in the future.

However, fusion energy research is undergoing two paradigm shifts that will jointly shape its future. First, it is transitioning from science to technology as more and more technological applications are providing different approaches to the future commercialization of electricity generated from fusion power. Second, it is transitioning from public to private funding as more and more private companies are entering the newborn fusion industry. This large influx of private funding is shifting the focus of fusion energy research from full disclosure of scientific results within the global fusion community to stricter enforcement of intellectual property rights that could have a negative impact on future research.

Now more than ever fusion energy research needs a regulatory framework to guide this transition. This paper plans to build a systemic approach to policymaking in fusion energy research to show that science and innovation policies that favor openness in science can provide greater economic

and social utility to both the publicly and privately funded research communities in nuclear fusion. The main policy recommendation derived from this paper urges the governments that are currently sponsoring private endeavors in fusion energy to keep science open in exchange of public funding.

The systemic approach to policymaking derived from this paper can also provide a policy toolkit for managing complex and dynamic technologies in several other sectors, such as aerospace. Moreover, the implications for sustainability derived from this paper can assist the policymaking system with a multicriteria approach to assist the formulation and implementation of climate-change mitigation policies in other technologies of public interest, such as transportation.

References

Carayannis, E. G., & Draper, J. (2021). The Growth of Intellectual Property Ownership in the Private-Sector Fusion Industry. *Fusion Engineering and Design*, 173, 112815.

Claessens, M. (2020). *ITER: The Giant Fusion Reactor*. Springer International Publishing, Cham.

Dasgupta, P., & David, P. A. (1994). The New Economics of Science. *Research Policy*, 23(5), 487-521.

David, P.A. (2003) The Economic Logic of “Open Science” and the Balance between Private Property Rights and the Public Domain in Scientific Data and Information: a Primer, in Esanu, J.M. and Uhlir, P.F. (Eds.), *The Role of the Public Domain in Scientific and Technical Data and Information*, The National Academies Press, Washington, DC, pp. 19-34.

Jaffe, A. B., Newell, R. G., & Stavins, R. N. (2005). A Tale of Two Market Failures: Technology and Environmental Policy. *Ecological Economics*, 54(2-3), 164-174.

Merton, R. K. (1973). *The Sociology of Science: Theoretical and Empirical Investigations*. University of Chicago Press.