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Collaborative Advantage: Creating Global Commons for Science, Technology, and Innovation

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Collectively solving problems shared by many nations requires a new global science and technology commons, which could be modeled on successful past experiences.

A DISCUSSION OF

The Next 75 Years of Science Policy

What was once described as the "American Century" of political and technological dominance is giving way to a polycentric world. In this new order, the fate of nations will depend on international collaboration for innovation and prosperity, particularly as global challenges including disease, poverty, energy deficits, and climate change threaten all. The innovations needed can no longer be produced by only a few nations, nor can the benefits be confined to those few. Developing such innovations, however, will require collaborative efforts at a global scale that go beyond anything previously attempted.

In the postwar decades, the United States pursued a techno-nationalist path in research and development that became a global norm. The US government was capable of funding research projects at far higher levels than other governments; US firms also directed substantial portions of revenue to R&D, extending federal efforts. The world's most advanced R&D laboratories included the largely independent Bell Labs and Xerox PARC, while companies like IBM, GE, RCA, DuPont, and Polaroid were engaged in significant basic and exploratory research. To varying degrees, these labs followed in the footsteps of the "Big Science" organizations of the federal labs such as Lawrence Livermore, Oak Ridge, the National Institutes of Health, and others. And, of course, significant federal funding also flowed to industry as part of the military's embrace of the R&D enterprise. Government and private labs pioneered innovations that gave the United States leadership in the introduction of new technologies, increased productivity, and created new consumer demands. The nation's universities trained large numbers of science, technology, and innovation (STI) workers, while attracting top talent from around the world.

In the twenty-first century, America remains the global leader in science and technology, but other nations are beginning to stand alongside it. Repeated calls for increased R&D funding, stronger patent protections, more surveillance against technological espionage, and greater support of American industry betray a palpable anxiety about America's standing in the world in terms of economic and military power. Although not all the policies proposed to reinvigorate American innovation are inherently techno-nationalist, often the ways in which they are justified and framed are based on notions of outcompeting other nations—formerly the Soviet Union and

Japan, now increasingly China. Policies are deliberated on the assumption that the United States needs to spend more on R&D than other countries, graduate more scientists and engineers, restrict outflows of STI, and sequester global science and engineering students and workers to deny access to them by other countries. Implicit in such proposals is the idea that the international creation and application of STI is a zero-sum game in which one country wins only at the expense of others.

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We argue that abandoning this techno-nationalist approach and instead investing in systems of global innovation commons, modeled on successful past experiences, and developing new principles and policies for collaborative STI could bring substantially greater benefits—not only for the world, but specifically for the United States. Key to this effort will be creating systems of governance that enable nations to contribute to the commons and to benefit from its innovations, while also allowing each country substantial freedom of action.

BUILDING COMMONS FOR SCIENCE AND INNOVATION

The competitive and insular tone of contemporary discourse about STI stands in contrast to our era's most urgent challenges, which are global in scale: the COVID-19 pandemic, climate change, and governance of complex emerging technologies such as gene editing and artificial intelligence. These global challenges, we believe, require resources, scientific understanding, and know-how that can best be developed through common resource pools to enable both global scale and rapid dissemination. Moreover, aside from moral or ethical considerations about sharing such innovations, the reality of current globalization means that solutions—such as pandemic vaccines—must spread beyond national borders to fully benefit the world. Consequently, each separate national interest will be better served by collaboratively building up the global stocks of STI as public goods. Global scientific commons could be vital in addressing these challenges, but will require new frameworks for governance that are fair and attractive to many nations while also enabling them to act individually.

A valuable perspective on the governance of common pool resources (CPR) can be found in the work that Nobel laureate Elinor Ostrom did with her colleagues beginning in the 1950s. Ostrom, a political scientist, studied how communities that must share common resources—water, fisheries, or grazing land—use trust, cooperation, and collective deliberation to manage those resources over the long term. Before Ostrom's work, many economists believed that shared resource systems were inherently unsustainable because individuals acting in their own self-interest would ultimately undermine the good of the group, often described as "the tragedy of the commons." Instead, Ostrom demonstrated that communities can create durable "practical algorithms" for sharing pooled resources, whether that be irrigation in Nepal or lobster fishing in Maine.

Over the years, Ostrom and her colleagues' work yielded a set of design principles for CPR. These grew out of case studies of CPR governance systems to foster and protect resources and allocate them fairly among members. These design principles address, first, who is part of the community and what the boundaries of the resource are. Second, all members participate in setting and modifying rules, which include what they should contribute to the common pool and what they can withdraw. Finally, there are sanctions for rule violators and low-cost ways to resolve disputes between members. Ostrom studied small CPR governance institutions, but she noted they could be part of larger systems organized in multiple layers of nested organizations.

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Ostrom and her colleagues derived and verified these design principles across hundreds of case studies of durable community holdings of CPR around the world. We believe the principles might be used to build global STI commons governance systems equal to the task of addressing important threats common to the international community, while allowing each country substantial freedom of action. And we propose that these design principles be adapted to address characteristics particular to STI development as well as moral and ethical issues, including equity in access and use of new knowledge and technology for the purpose of addressing global problems at the local level.

A viable institutional framework to govern a global STI commons would need buy-in from a highly diverse group of national governments and interested organizations. The institutional governance structure would have to ensure representation of the various economic and cultural interests of governments as well as regions. It would have to ensure that smaller and poorer countries were treated fairly. It would have to be structured to reduce temptations of governments to “free ride”— taking resources from the common pool without contributing to the whole. And it would need to fairly apportion access to innovations developed using commons resources. As in Ostrom’s successful commons governance systems, there would need to be trusted monitors who could ensure that every country both contributed and withdrew their fair share. And in addition to all of these formidable challenges, the STI commons would need to remain independent from nationalist interests that might undermine the principles of the commons or constrain its governance.

This sounds like a nearly impossible set of tasks, particularly in a world now facing significant environmental and governance issues. But we suggest that the European Organization for Nuclear Research, commonly known by the acronym for the organization’s original French name, CERN, appears to have successfully developed precisely such an STI common pool management institution. Founded to support multinational research in subatomic physics, CERN has broadened its research scope and endured over decades, providing not only important technological innovations, but a certain level of stability as the world around it changed. Following Ostrom’s approach, we begin with an overview of CERN’s governance system and then suggest next steps that might enrich our portfolio of design principles.

THEORETICAL PHYSICS AS A COMMON POOL RESOURCE

CERN officially came into being in 1954 and has thrived in an often chaotic global environment. Driving forces in its establishment included physicists Niels Bohr and Werner Heisenberg, who were concerned that progress in subatomic physics increasingly required Big Science experimental facilities. Those were only available in the United States and the Soviet Union, where the work was associated with the development of weapons. European scientists had to go to one of these countries, particularly the United States, to do such research, and many of them wanted to avoid contributing to knowledge that would increase the threat of nuclear weapons.

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In 1949, a proposal for the laboratory was made at the European Cultural Conference, and it was further promoted by American physicist Isidor Rabi at a United Nations conference in 1950. Under the proposal and initial founding document of the organization, the group of 12 member nations would finance and build one or more international laboratories for research on high-energy particles, creating an important international common pool resource. To avoid exploitation of the facilities for development of nuclear weapons, the convention stated: “The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.” These have remained guiding criteria in establishing the open use of CERN’s work and delimiting what research can be done there.

The 12 founding states—Belgium, Denmark, France, the Federal Republic of Germany, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and Yugoslavia—were diverse. Some had been foes in World War II while others remained neutral; some were relatively rich and technologically advanced while others were not. By 2020, the organization had a budget of $1.25 billion with 23 member states, and 11,399 researchers affiliated with 78 countries, including the United States, had used CERN’s facilities.

CERN has surmounted a number of challenges that generally face common pool resource organizations and international organizations in general. These have included developing a governance structure that gives voice to members that vary greatly in size, wealth, and cultural values; designing a funding contribution system seen as fair to all; and providing rewards that make participation highly valued by members with diverse needs. And finally, the organization has established boundaries that give advantages to members but allow, and even encourage, spillovers of the common pool resources.

These spillovers have been considerable. In addition to technological achievements, including supporting pathbreaking research in subatomic physics, CERN has nurtured technology that is now used around the world—most notably, the World Wide Web and the first web server. These innovations, which are credited to the Englishman Tim Berners-Lee and the Belgian Robert Cailliau, grew out of CERN’s uniquely collaborative culture. In addition, the organizationpioneered the touchscreen, medical technologies such as imaging used in cancer detection, and modeling tools, among many other innovations.

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Today, CERN members include low-income nations with few technological resources as well as high-income, technologically advanced nations. In the early 1990s, Bulgaria, the Czech Republic, Hungary, Poland, Romania, Serbia, and Slovakia became members. Russia was an observer for many years. In 2020, Azerbaijan, Estonia, Georgia, Latvia, and Montenegro all sent participants, and China sent 334 observers. Funding of the organization is shared according to the size of each country's economy (readjusted periodically so as to account for different rates of growth). Germany, for example, now provides about 21% of the budget, while Serbia provides less than a quarter of a percent. Countries like Germany, France, and the United Kingdom benefit by being able to share the cost of very expensive advanced facilities. Small countries also benefit from having a voice in setting research and policy agendas, developing connections, and having early access to research findings and the opportunity for their own scientists and innovators to collaborate in world-class research.

CERN's organizational operations reveal important principles for developing STI global commons. The organization's governance system provides some shelter from national political constraints: low-income countries have full rights of membership but with lower financial contributions. In addition, there are options for participation by nonmembers through associate and observer status. Importantly, individual scientists are able to participate in global-standard science and have access to resources while maintaining their permanent residency in their home countries. And, conversely, CERN as a global science organization can draw on global resources without requiring individuals to migrate. Although CERN is undoubtedly Eurocentric in culture and practice, reflecting its origins and initial political purposes, its operating principles are not intrinsically constrained to a geographic region or geopolitical regime.

In this way, CERN demonstrates that an STI global commons is not inherently restrictive and can be expanded to incorporate other scientific values and approaches, including non-Western science and knowledge, as its membership grows. Thus, the development of operating principles is a dynamic process that will follow a broadly inclusive membership rather than prescribed rules. That said, the guarantee of free inquiry, discussion, and debate is essential to STI governance and may conflict with some national governance restrictions.

CERN is governed by a council made up of representatives of each of the 23 member states. Each state has two delegates: one representing his or her government's official interests, the other representing its national scientific interests. Each member state has a single vote on policy matters such as which programs to support. Most decisions are made by a simple majority, but the council aims for a consensus. The council appoints the Scientific Policy Committee, which evaluates the scientific merit of activities proposed by physicists and makes recommendations. Scientific Policy Committee members are elected by current members based on scientific eminence without regard to nationality and can include scientists who are not from member states.

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CERN has developed a capacious approach to membership, which could be a model for future STI collaborations. In addition to its 23 member states, it has eight associate member states, including India, Pakistan, Türkiye, and Ukraine, as well as observers, including Japan and the United States (Russia was an observer from 1993 until its status was suspended after its invasion of Ukraine in 2022). Observers attend meetings and make financial contributions to projects. The United States was given observer status in 1997 upon making a contribution of $531 million to the large Hadron Collider, after Congress withdrew support for the well-over-budget and politically contentious Superconducting Super Collider project.

This move on the part of the United States was a significant validation of the vision of CERN as a scientific global commons. As a collaborative resource, CERN appeared to be a more efficient investment in Big Science for US resources than the go-it-alone model of the Super Collider. And CERN also has a governance regime that could better navigate small internal and larger geopolitical disputes. Finally, to the extent that the innovations from CERN were intended to be shared with the world, investments in the common pool have also benefitted the rest of the planet. CERN's endurance shows that it found a way both to accommodate countries with widely different needs and to provide a means for ensuring that decisions did not discriminate against smaller or less affluent countries, while providing benefits for all.

DEVELOPING THE GLOBAL STI COMMONS

As Ostrom noted in 1990, "'getting the institutions right' is a difficult, time-consuming, conflict-invoking process" when structuring successful common resource governance systems. When Ostrom sought to identify governance principles for CPR, she and her collaborators looked at examples that had endured for decades or sometimes centuries. Similarly, CERN's principles have stood the test of time, serving the interests of its highly diverse members while continuing to attract new ones. But there is a crucial difference: Ostrom's CPR organizations governed the use of limited natural resources, while CERN is concerned with the constant creation of new resources—scientific and technical knowledge. Building on Ostrom's work and CERN's example, we believe there are important lessons for the governance of STI efforts to solve emerging global problems.

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Although some attributes of CERN's governance system were the result of specific national, institutional, disciplinary, and geopolitical circumstances, the system demonstrates flexibility that may be important for future efforts. For example, CERN's utility was increased beyond its primary focus of subatomic physics because it attracted a broader range of innovators, who worked on a number of far-reaching innovations. Key to its success is that it is governed by respected experts in STI fields from many countries, which has helped CERN avoid "capture" by military-industrial or parochial economic industries.

To advance the concept of creating global STI commons organizations, we propose following Ostrom's example by building a body of knowledge and practice. Just as Ostrom studied working systems, we propose finding further instances of successful (and unsuccessful) systems for the development and governance of global STI commons. Examples might include the Scientific Committee on Antarctic Research, which established a global geography for science, as well as recent initiatives to address the COVID-19 pandemic. Efforts to collect and study examples would examine failures in addition to successes, such as the perceived unfairness of international regimes to govern intellectual property rights. Identifying best practices through experimentation, iterative development, and evaluation will be crucial in establishing ground rules for new collaborations.

CERN provides a model that offers an intriguing glimpse of the expansive possibilities of well-designed global STI collaborations. Among its key achievements have been constructing an alternative institution for innovation at a moment when techno-nationalism was laid bare by the devastation of World War II and entrenched interests had slackened, and then surviving the emergence of the Cold War and growing tensions. Similarly, the challenges of the current moment could provide an impetus and opening for an alternative to today's nationalized innovation systems.

Near the end of her life, Ostrom suggested that rather than simply waiting for global solutions to climate change, public and private actors and researchers should encourage the emergence of a polycentric system to start the process of reducing greenhouse gas emissions. This vision suggested that rather than delaying action until development of a global regime to control carbon emissions, small, complementary local efforts could begin to make changes at multiple levels. The purpose was twofold: the polycentric system not only starts the process of reducing greenhouse gas emissions, but it also acts as a spur to international regimes to do their part. We suggest that the current environment provides incentives and opportunities to begin developing a variety of new STI common resource pool governance systems that could be put to work solving our looming problems while encouraging the development of new global initiatives.

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