The Future of International Exchanges in a Post-Pandemic World

Chapter 3

Virtual Trust Networks in Transnational Research

THE FUTURE OF INTERNATIONAL EXCHANGES IN A POST-PANDEMIC WORLD

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Virtual Trust Networks in Transnational Research

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International scientific exchange is stronger between the United States and Europe than among any other regions of the world. The interconnections include educational and scholarly exchanges, immigration, cooperative projects, and extended scholarly visits. One quarter of research project awards made by the US National Science Foundation mention Europe as subject or partner. In 2019, the Web of Science catalogued close to 140,000 scholarly articles published between a European author and a United States author. The United Kingdom, Germany, and France made up half of all of these US partners. Collaborations between Europe and the United States tend to be more highly cited than other bilateral relationships.

International exchange is supported by formal agreements. The European Union and the United States have treaty relationships embodied in the EU-US Agreement for Scientific and Technological Cooperation and treaties governing space cooperation. Bilateral cooperative agreements have been signed between the United States and Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Norway, Poland, Romania, Slovakia, Slovenia, Sweden, Switzerland, and the United Kingdom. The formal relationships include "big science" investments in equipment such as telescopes and synchrotrons. Big science projects have included the International Space Station; the United States participation as an observer in the European Organization for Nuclear Research (CERN); large-scale astronomy and astrophysics projects; polar observatories; and the Human Genome Project.

However, while these formal agreements set the foundation for international relationships, the majority of US-European cooperative activities are initiated and carried out without the assistance or recourse to formal agreements, through bottom-up connections made between researchers themselves (Leydesdorff, Bornmann, and Wagner 2019). Looking through the lens of published research articles, collaborations between Europe and the United States in the sciences and engineering numbered about 30,000 in 2019; while this is similar in volume to US-China publication output, it does not include other forms of exchange such as students, facilities use, and meetings. By subject, cross-Atlantic collaborations show the greatest numbers in astrophysics, biochemistry, biotechnology, chemistry, medicine, physics, and pharmacology. Cooperation between the UK and the US was dominated by neurosciences, physics, environmental science, and engineering. Physics, chemistry, neuroscience, engineering, and materials science are the top subjects of cooperative research between the US with Germany and France.

These direct exchanges tend to occur between high-esteem partners, often from elite institutions, with relationships cemented at conferences or research sites. Social capital built up between universities through scholarly exchange establishes trust networks that reduce the risk of collaboration (Burris 2004). These networks are at a premium in high stakes situations, when there is not time to build up social capital through other means. The 2020 COVID-19 pandemic did not alter this pattern of cooperation (Fry et al. 2020). However, quarantining closed down face-to-face meetings and student exchanges and forced the broad adoption of virtual modes of communication. The shift to online communications opened opportunities for participation and trust-making among people who have historically been excluded from the elite social networks. Looking forward, the resilient US-EU relationships may expand to accommodate new trust-building spaces created during the COVID-19 pandemic that lay the foundations for an era of inclusivity and innovation. Our challenge will be in measuring changes in trust networks, which may initially manifest outside of standard scholarly output industries in activities such as working groups, clinical guidelines, pre-prints (Weissgerber et al. 2021), and published monographs or internal technical reports.[1]

Historical trends in international scientific exchange and interdependence

Over the last 50 years we have seen increasing internationalization of scientific exchange (Wagner and Leydesdorff 2005). While nations invest in research to drive innovation, increasingly these efforts are multilateral, driven by global challenges that require multinational and multidisciplinary collaboration. In 2019, collaborative research articles (more than two authors) accounted for nearly 90 percent of European publications indexed in the Web of Science. Sixty percent of articles were authored by researchers from two or more nations. International organizations such as the World Health Organization and the European Commission fund multi-year work programmes that stimulate cross-national scientific cooperation. However, using research article authorship as a measure, most scientific collaborations are bottom-up partnerships between researchers at highly-ranked institutions, funded by several national agencies and involving a highly mobile workforce (Wagner, Park, and Leydesdorff 2015).

In this constantly changing environment, trust is at a premium. There is intense competition among researchers to establish a personal "trust certificate," accomplished through associations with trusted entities: esteemed professors, employment at highly ranked institutions, and publishing in prestigious journals. Travel and face-to-face meetings are critical; close to 90% of collaborations begin face-to-face. While these can exclude those unable to travel, it can also open doors. One example is the fortuitous meeting of Jennifer Doudna and Emmanuelle Charpentier at the 2012 Annual Society of Microbiology conference, which evolved into a cross-Atlantic research group: a French professor in Sweden, a Polish student in Austria, and a German student, Czech postdoc, and American professor in the US that developed CRISPRcas9 gene editing technology, for which they were awarded the Nobel Prize in 2020 (Doudna and Sternberg 2015).

Nations can foster (or hinder) scientific exchange through visa and immigration policies and procedures, such as visa duration, travel for scientific meetings, nonimmigrant visa categories for students, reciprocity agreements, and change of status procedures (National Research Council 2005; Wagner 2002). Many US-EU relationships begin when students travel abroad to study. In 2018, pre-pandemic, over 188,000 students from the United States, or 55% of all students going abroad, studied in Europe. Students traversing the Atlantic to study in the United States numbered 129,000 in that same year. The largest Atlantic exchange is between the United States and the United Kingdom, followed by Italy, Spain, and France. Another chapter in this volume explores the impact the pandemic may have on future exchanges.

To build innovative capacity, nations implement policies that attract talent and reward researchers for international collaborations (Adams 2013). In the EU this comes in the form of research funding priority for groups that have cross-national participation (European Commission, n.d.). In Asia Pacific countries, this has tended

1 For example, see the US National Academies Response and Resilient Recovery Strategic Science Initiative: https://www.nationalacademies.org/our-work/response-and-resilient-recovery-strategic-science-initiative-a-rapid-multidisciplinary-scientific-capability-for-scenario-analysis.

toward awards for research publications with multi-national author lists.[2] Overall, bibliographic databases underpin both outcome measurement and policy development,[3] and tend to further solidify the radius of trust among elite institutions. The institutional incentives for researchers in the Asia Pacific region have started to crack through US-EU dominance: over the last 10 years, there has been a notable increase in Chinese universities included in the top-100 rankings.

Infrastructure and institutional connections

As scientific collaboration has become more international, so has its governance. Once the purview of academic institutions and nations, collaboration is now supported through transnational infrastructures. The Internet is perhaps the most foundational. Started as separate, competing national initiatives, the Internet became a truly global information infrastructure (Gillies and Cailliau 2000). Its workings are governed by the IETF, an open, non-national, and cross-sector community of network designers, operators, vendors, and researchers bound by a shared mission. In large part, work of the IETF has enabled virtual communications during the COVID-19 pandemic, ensuring web browsers can support voice, video, and real-time data calls.

Over the last 30 years, access to information on the Internet has become as or more important than travel for research collaborations. National cyberinfrastructure policies and funding have supported the expansion of national information superhighways, including National Research and Education Networks (NRENs) in over 65 countries around the world.[4] Gaps in coverage have been made painfully obvious during the COVID pandemic, highlighting resource limitations in rural and lower-income populations—and also innovations implemented in resource-poor countries that could be adopted more broadly, such as regional community development and resource pooling seen in African NRENs.[5]

As research moves into the digital age, library resources have moved online, making it more possible—at least theoretically—to access knowledge. Initially seen as a step toward democratizing knowledge, as with collaborations, information has remained in esteem silos, locked behind firewalls and paywalls (Leydesdorff and Wagner 2008). Work at local and national levels by universities and funders has led to development of open access principles. Policies and practices are being adopted that enable broader sharing of research outputs. However, coordination between entities has been problematic, creating a plethora of at times contradictory policies. This has created confusion for researchers, publics, and information platforms alike, and has slowed adoption and accrual of benefit (Bello and Galindo-Rueda 2020).

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2 For example, see: Qiu, Jane. 2014. "China's Funding System and Research Innovation." *National Science Review* 1, no. 1: 161–163. https://doi.org/10.1093/nsr/nwt034; and Australian Research Council. 2020. "International Policies and Strategy." Last modified December 18, 2020. https://www.arc.gov.au/policies-strategies/strategy/international.

3 Annual international rankings of the bibliometric-based rankings include the *Academic Ranking of World Universities*, the *Performance Ranking of Scientific Papers for World Universities,* the *University Ranking by Academic Performance*, the *CWTS Leiden Ranking,* the *SCImago Institutions Rankings,* the *Center for World University Rankings,* and the *Nature Index Annual Tables* published by Nature Research.

4 See GEANT web page: https://www.geant.org/About/NRENs and Internet 2 web page. https://internet2.edu/community/global-partners/. Accessed 8 Jan 2021.

5 See AfricaNet3 web page: https://africaconnect3.net/. Accessed 8 Jan 2021.

In this digital research ecosystem, identity and reputation are core components for establishing trust. Over the last 20 years, a web-based global open infrastructure has emerged, composed of data standards, persistent identifiers, and normative behaviors (Haak et al. 2012). With the implementation of these infrastructure components, including digital identifiers for research objects, researchers, institutions, data, software, and more, it is becoming possible to establish online identity, trust, and transparency. With these identifiers, we are just starting to be able to measure nuance in collaborations (Haak, Greene, and Ratan 2020). An early study with ORCID data, for example, provided a glimpse into researcher mobility at a scale not before possible (Bohannon 2017). That these components, as with IETF, are open community efforts, means it is also becoming more possible to draw networks of connections between researchers, institutions, and contributions (Fenner 2020), a boon for policymakers and researchers alike keen to understand impact without interfering with the research process (Haak, Meadows, and Brown 2018).

However, for these open infrastructures to be adopted on a global scale means that individuals, institutions, and nations must have trust in them. Governance must be clearly defined and participatory, giving voice and agency to multiple constituencies. Sustainability of services must be paramount, and community benefit must be obvious and forever first (Bilder, Lin, and Neylon 2015; Skinner 2019). DataCite, CrossRef, and ORCID are open infrastructure providers that have been successful at creating global communities of practice, which in turn have developed many innovative products and services enabling researchers to collaborate within and across nations. Different from the challenges of open access policy, here the plethora of products responds to the specific needs of disciplines and national policy—and with appropriate use of web-based standards can enable cross-platform information sharing. A primary policy challenge is thus adoption and use of the underlying standards, which, while developed through grass-roots community efforts, may have weak governance ties with national policies. The German National Research Data Infrastructure[6] is one new national initiative bucking this trend.

The Research Data Alliance (RDA) initiative combines top-down formal agreements with bottom-up collaboration, building international trust through shared norms (Berman and Crosas 2020). As research digitization proceeded, funding for cyberinfrastructure has lagged behind data sharing and data-driven exploration needs. Researchers were roadblocked by sparse or inadequate standards, models, and frameworks. The RDA was established in 2013 as a joint effort of three national agencies: the European Commission, the United States National Science Foundation and National Institute of Standards and Technology, and the Australian Government's Department of Innovation. RDA functions similarly to IETF, with community-driven working groups and an explicit governance structure. It is an example in practice of how stakeholders can come together across disciplines, sectors, and nations to create inclusive socio-technical norms that enable research collaboration, with successes including harmonizing publisher data sharing policies (Hrynaszkiewicz et al. 2020) and FAIR compliance (Bahim et al. 2020). Measuring the impact of RDA working groups and outputs on international collaboration—including the diameter of trust among elites—should be a research policy priority.

Support for EU-US partnerships is also sustained by governing bodies that aid scientific collaboration. These include organizations that bring together government officials (sometimes joined by scientists and engineers) and those organizations representing scientists and engineers. The Organization for Economic Co-operation and Development (OECD), a cooperative think tank established and maintained by member governments, hosts a Global Science Forum to discuss governance issues. The Global Research Council (GRC) brings together heads of science and engineering funding agencies from around the world to share data and best practices for research collaboration. GRC advises on peer review, data sharing, cost sharing, capacity building, and research integrity. Academies of science, medicine, and engineering often serve a role in supporting

6 National Research Data Infrastructure web page: https://www.nfdi.de/en-gb. Accessed 28 January 2021.

cooperation; the Interacademy Partnership of academies brings the national entities together to support science, advise policy, promote science education and encourage development. The International Science Council represents scientific unions and associations to provide inputs to science and policy decision-making. Science diplomacy is evolving to encompass increasing openness in science, more national actors, and the need for new approaches to diplomatic training, particularly to address global challenges. The US and European countries serve as the core of these organizations.

Post-COVID analysis

As the world emerges from the COVID-19 pandemic and lockdowns reduce in frequency, we expect to see lasting changes in how scientists collaborate. More are willing to engage in online discussions. Opportunities for face-to-face meetings will change, as funders and professional societies alike offer more virtual gatherings. These may encompass primarily business meetings—review, leadership, and planning activities, but are likely to also include expanded training and continuing education courses. Where before, face-to-face meetings were assumed, more now have had success using online tools for many applications, and have experienced the benefits of increased participation, opportunity for including previously excluded voices and communities, and are willing to forge ahead in purpose-built virtual spaces that enable collaboration, iteration, and sharing.

Initial analyses of publication data from January to April 2020 indicate that collaborative activities increased between highly ranked institutions, compared to the previous 24 months (Fry et al. 2020). At the same time, we also see increased use of pre-prints, particularly in biomedicine, as an accepted mode of information sharing. In the US at least, campus lockdowns have focused on undergraduates, allowing graduate student seminars and research spaces to continue operation. International student mobility has been seriously decreased, with ramifications that may take years to realize (Roach and Skrentny 2021). Graduate research is an apprenticeship of minds, techniques, and resources. We may see more national policy initiatives to recruit local talent; at the same time, the international collaboration networks built up over the last 50 years have been critical in establishing the interpersonal and institutional trust necessary to rapidly and efficiently respond to the COVID-19 pandemic, from basic research to developing a vaccine and community awareness programs. Transnational exchange must continue to ensure resilience for other global challenges.

Linkages between inclusion and innovation

Building trust networks should be a primary consideration of US-EU research policy. The World Health Organization (WHO), established in 1948, older and larger than RDA and IETF, also demonstrates the practicality and effectiveness of building international consensus on research norms through community working groups. WHO is charged with engaging across its member organizations to secure global cooperation and international agreement on matters relating to the initiation and promotion of global health standards. These are complex challenges, and WHO has developed an intentionally inclusive team-based approach that acknowledges the degree to which this work transcends any one nation, institution, or researcher (Guler et al. 2018). WHO projects have an up-front statement of values, and they fund and train project management personnel to support debate and diversity of views and experience.

The process of developing norms and standards is slow and laborious, but this work makes spontaneous collaboration less costly and more efficient. There are specific components of the consensus models of RDA, IETF, and WHO that drive success: a mission, clearly articulated goals, creative and committed staff driven by the mission, and a clear framework for tracking progress and sharing results. What RDA, IETF, and WHO demonstrate is that a specific intention to ensure diversity of perspectives and include multiple community stakeholders enables scientific collaboration as an emergent trust network, a new "open institution" on par with any nation (Wagner, Park, and Leydesdorff 2015).

What we should understand from the examples of IETF, RDA, and WHO is that diversity and inclusion drive effective research policy and practice. What we should learn from the COVID-19 pandemic is that community inclusion is necessary. That we have communities that are unwilling to be vaccinated or are willingly spreading contagion is a failure of inclusion. Maintenance of elite, exclusive networks runs counter to the open values of science. We need broad perspectives to simulate research and innovation across all areas of endeavor, and we need community engagement for these innovations to be adopted.

Historically, US and EU policymakers have defined research excellence in Enlightenment terms to which most other nations have been expected to adapt. Practices such as peer review, data sharing and validation, open debate and attribution have developed over centuries in Europe, later in the US, and from these nations, to other nations. These norms are held, not just at the national levels, but at the international level, and all participants have been expected to adjust themselves to these norms. Here is where scientific collaborations can leverage their emergent "meta-nationhood" and establish discourses and shared language, create inclusive spaces, and take the time to imagine futures and discuss ethical implications of technological advances in discussions about values, problems, and priorities (Kläy, Zimmermann, and Schneider 2015).

Recommendations for policy

Transatlantic scientific cooperation and collaboration has grown over decades out of a common set of expectations, norms, and recognition of benefit. The robust connections that are largely self-organizing and self-sustaining are a sign of strength. In the post-pandemic era, we can expect these shared norms to maintain and increase EU-US connections. Further, new trust networks may emerge that better inculcate practices of openness, reciprocity, and verification, all critical to the health of global science.

In the past, the focus has been *personal* networks through training, meetings, and shared facilities. To this should be added scientific project managers who can guide team formation and interpersonal dynamics, as well as assist with the curation and custodial recordkeeping necessary for effective open collaboration. Funding agencies, professional societies, and institutions play a formative role in these efforts (Chodhaki et al. 2020).

As scientific exchange becomes more open, with more online collaboration, we need to reflect that openness in terms of who is participating (and where) and at the same time develop *digital* trust networks through new kinds of infrastructures. These include international identifier and data exchange standards, such as DOIs and ORCIDs, embedded into regular scientific workflows, enabling transparency in the who-what-where of research exchange. In the US, the Office of Scientific and Technical Policy should continue to work across agencies to cohere data sharing policies and practices.

In addition, international grassroots organizations, fostered by international agreements, are powerful normative frameworks with the creativity and flexibility necessary to build trust for more inclusive cross-national and cross-disciplinary collaboration. Networks of networks will emerge; these organize most effectively from the bottom up. Policymakers can provide incentives, but should not seek to create command-and-control structures.

And finally, as the webs of networks grow, we must be able to measure their strength and effectiveness. To do this, we need equally creative, inclusive and flexible techniques and indicators, such as those promoted through the Declaration on Research Assessment (DORA) framework, integrated into workflows so that we can track, monitor and measure scientific exchange without interfering with the research process.

Together, these four pieces—digital, interpersonal, governance, and measurement infrastructures—will enable the growth of international trust networks and through those, the fifth era of international scientific collaboration.

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