National Center for Science and Engineering Statistics

InfoBrief

International Collaboration in Selected Critical and Emerging Fields: COVID-19 and Artificial Intelligence

NSF 24-323 | April 2024

Clara Boothby and Benjamin Schneider

Research collaboration is a critical strategy for pooling resources, sharing expertise, and accelerating innovation, and institutions may use collaboration to synthesize novel ideas and bridge knowledge or material gaps (Katz and Hicks 1997; Lee, Walsh, and Wang 2015; Wagner et al. 2001). Ongoing research on the transformative potential of artificial intelligence (AI) and the mitigation and treatment of COVID-19 in 2020 are two cases in which scientific progress has been important. Both fields have been recognized as national priorities (**https://www.whitehouse.gov/priorities/**) and have complex challenges that both domestic and international institutions are motivated to overcome.

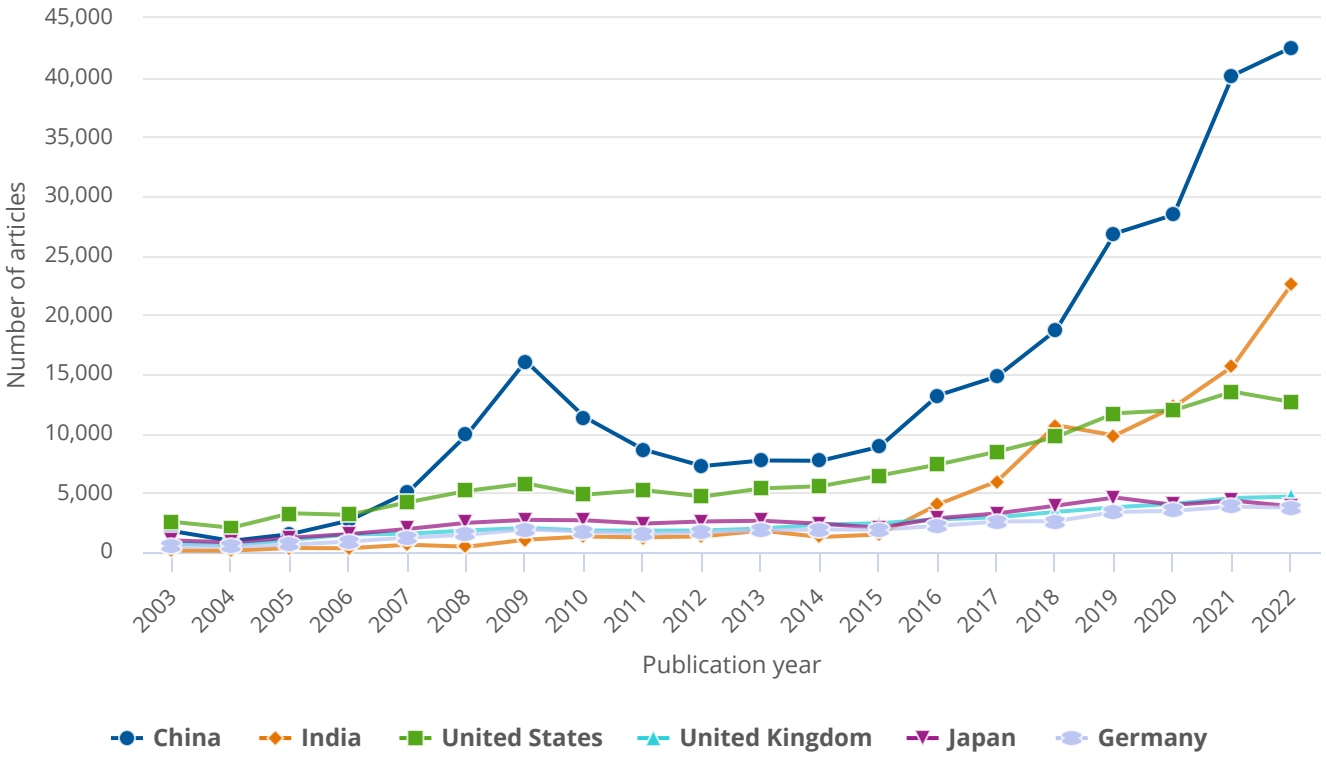
A country's collaboration patterns, both domestic and international, can indicate the presence of expertise or the necessity of knowledge and resource sharing, as countries tend to collaborate internationally less in fields when they have sufficient resources within their own borders (Chinchilla-Rodríguez, Sugimoto, and Larivière 2019). International research collaboration can provide a rapid response to societal challenges, including public health crises (Carvalho et al. 2023) or technological paradigm shifts, and strong international collaborators play a large role in shaping the direction and priorities of research fields worldwide (Leydesdorff and Wagner 2009). A concentration on domestic research can indicate the presence of sufficient domestic knowledge and resources or an interest in preserving in-house expertise. This InfoBrief examines the extent to which top producers of science and engineering (S&E) articles engaged in domestic and international collaborations in AI and COVID-19 research.

Growth in Artificial Intelligence Articles

Between 2003 and 2022, the number of published articles in AI grew faster relative to the number of articles in computer science,[1] due in part to the newness of the AI field compared with the more established field of computer science. AI articles worldwide grew by 1,100% during this period, reaching 123,402 articles in 2022,[2] or 4% of all S&E publications globally,[3] compared with 290% growth in computer science articles.[4] From 2017 to 2022, the six countries with the highest overall publication outputs[5] were also the countries with the highest AI research output (China, India, the United States, Japan, the United Kingdom, and Germany) (figure 1). In 2022, the top two producers of AI research articles were China (42,524 articles, or 35% of total AI publication output) and India (22,557, or 18%), followed by the United States (12,642, or 10%). Germany, Japan, and the United Kingdom published similar numbers of publications, ranging between 3,700 and 4,700 articles (3%–4%).

Figure 1

AI articles, by selected country: 2003–22



AI = artificial intelligence.

Note(s):
AI article counts refer to publications from a selection of conference proceedings and peer-reviewed journals in science and engineering fields from Scopus. The subset of AI articles was determined by All Science Journal Classification subject matter classification, supplemented by an algorithm that used a series of article characteristics to determine the field of papers published in multidisciplinary journals. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional addresses of the authors listed in the article. Articles are credited on a whole count basis (i.e., for articles produced by authors from different countries, each country is credited for one article). Data for all regions, countries, and economies are available in supplemental table SPBS-99 in Publications Output: U.S. Trends and International Comparisons (https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-99).

Source(s):
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed April 2023.

Collaboration Trends in Artificial Intelligence Articles

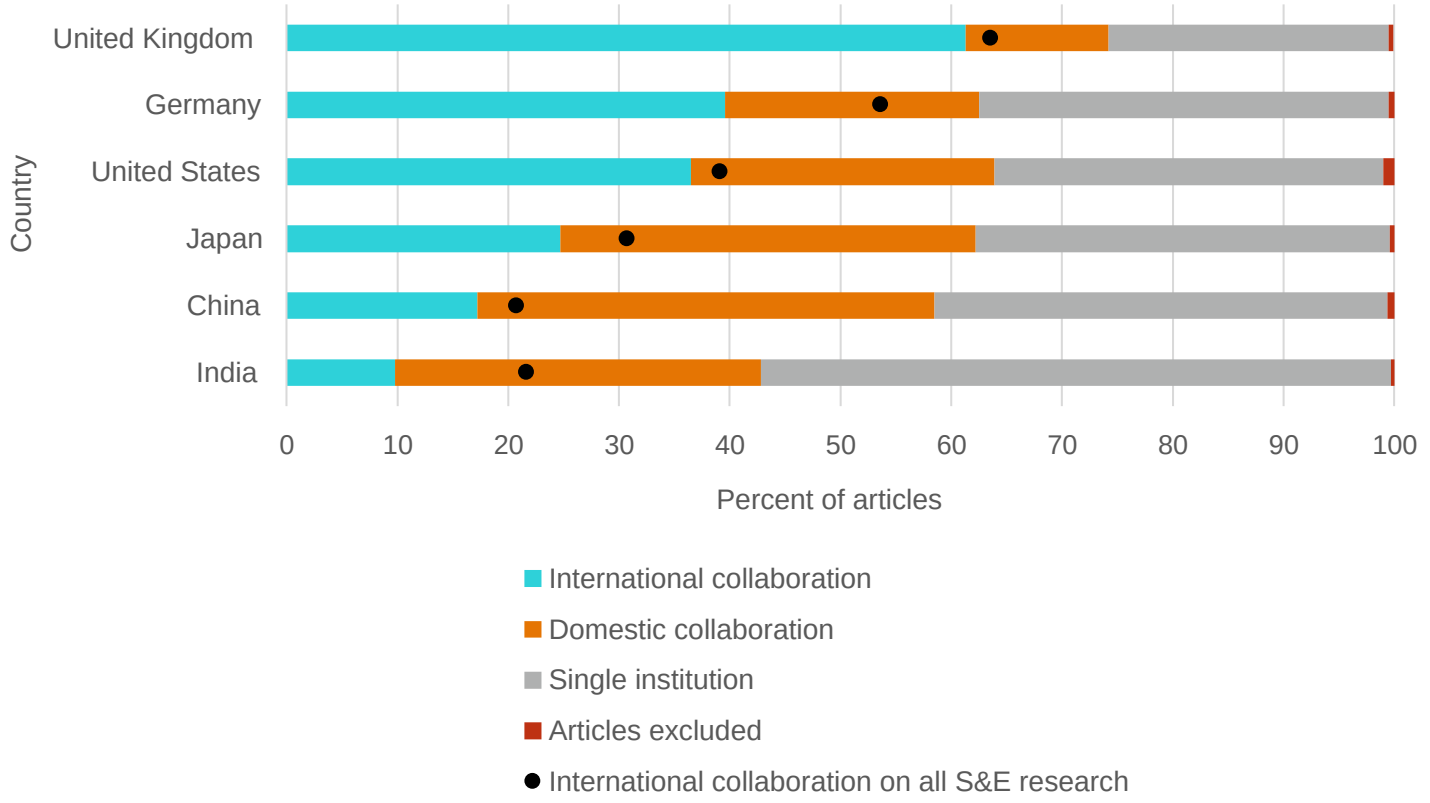
Coauthorship trends on S&E articles shed light on overall collaboration practices. The affiliations of authors to their home institutions and countries are used to infer whether collaboration has occurred across institutions, both domestically and internationally. Three types of collaboration are detailed in this InfoBrief, and an article is the unit of analysis. An article with at least one author from an institution of a given country is classified as one of three categories: an *international collaboration,* if an author from any other country is present; a *domestic collaboration*, if all authors are from the same country, but are affiliated with more than one institution; or a *single institution article* if all authors share the same institutional affiliation or the article is solo authored.

Collaboration Trends

From 2017 to 2022, 37% of U.S. research papers on AI were the result of international collaboration, placing the United States between the five other top producers of AI research papers, with the United Kingdom (61%) and Germany (40%) producing a higher rate of internationally collaborative research and with Japan (25%), China (17%), and India (10%) producing a lower rate (figure 2). Rates of international collaboration for the United States were slightly lower for AI research papers than for all S&E research papers (37% versus 39%). Likewise, across the other five top producers of AI research papers, rates of international collaboration were lower for AI research papers than for all S&E research papers. Compared with other countries, China had the greatest proportion of AI papers that were domestic collaborations (41%). Across the six top-producing countries, the rate of articles produced by a single institution were more common in AI research than in all S&E research (42% versus 26%).

Figure 2

International collaboration, domestic collaboration, and single institution publications on AI research and overall international collaboration on all S&E research, by selected country: 2017–22



AI = artificial intelligence; S&E = science and engineering.

Note(s):
AI articles are assigned to a country, or economy on the basis of the institutional addresses of the authors listed in the article. The subset of AI articles was determined by All Science Journal Classification subject matter classification, supplemented by an algorithm that used a series of article characteristics to determine the field of papers published in multidisciplinary journals. Articles are credited on a whole count basis (i.e., for articles produced by authors from different countries, each country is credited for one article). The percentages refer to the proportion of AI articles to feature collaboration or to the proportion of general articles across all fields to feature collaboration. Articles were excluded when one or more coauthored publications had incomplete address information in the Scopus database; therefore, they cannot be reliably identified as international or domestic collaborations. Data for all regions, countries, and economies are available in supplemental table SPBS-99 and supplemental table SPBS-33 in Publications Output: U.S. Trends and International Comparisons (https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-99 and https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-33).

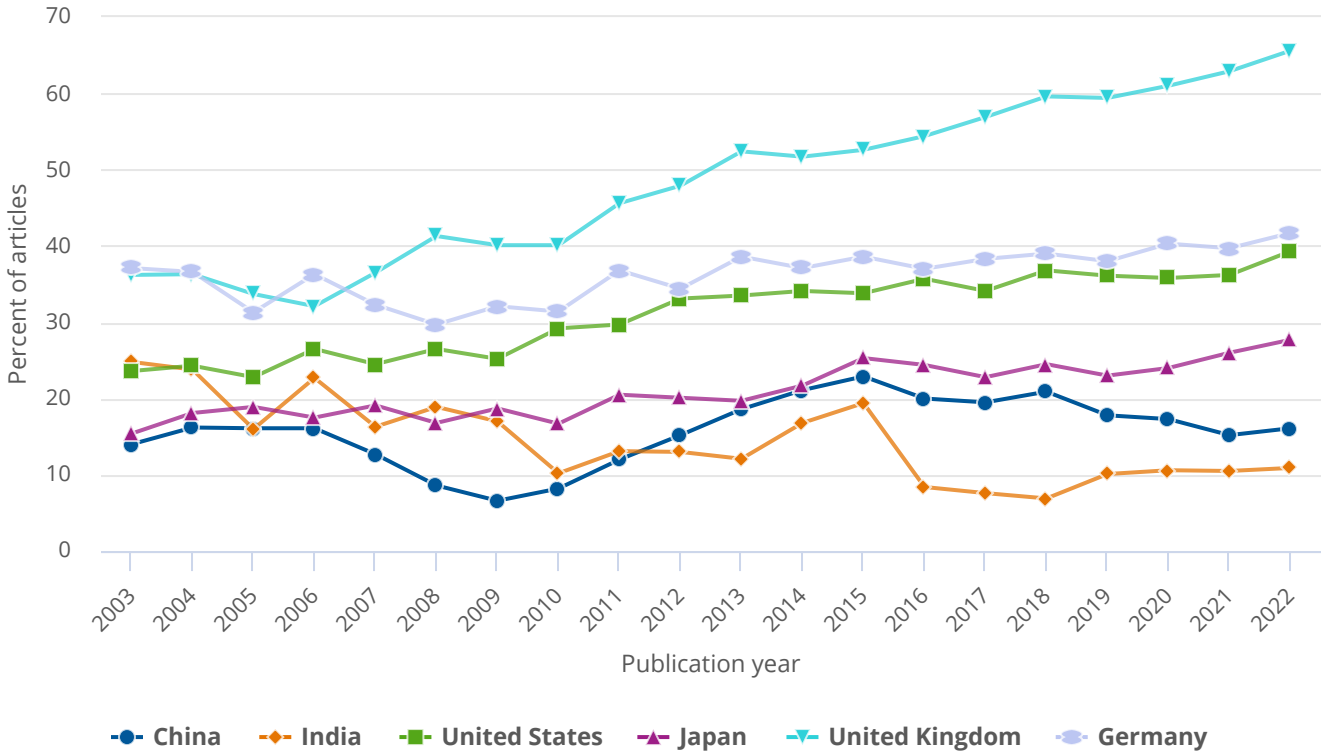
Source(s):
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed April 2023.

International Collaboration

Overall, scientific research has become increasingly collaborative over time (Gazni, Sugimoto, and Didegah 2012; Wuchty, Jones, and Uzzi 2007). Although the rate of international collaboration in AI publications has been smaller than the rate of international collaboration across all S&E fields over the past 5 years, international collaboration in AI articles has gradually increased overall between 2003 and 2022. By country, international collaborations in AI increased in Japan (from 15% to 28%), the United States (from 24% to 39%), Germany (from 37% to 42%), and the United Kingdom (from 36% to 66%) (figure 3). Over this same time period, India and China did not show an increasing trend, despite some fluctuation. For example, after China exhibited a period of increased international collaboration in AI research, from 7% in 2009 to 23% in 2015, the rate has since decreased to 16% in 2022.

Figure 3

International collaboration on AI articles, by selected country: 2003–22



AI = artificial intelligence.

Note(s):
AI article counts refer to publications from a selection of conference proceedings and peer-reviewed journals in science and engineering fields from Scopus. The subset of AI articles was determined by All Science Journal Classification subject matter classification, supplemented by an algorithm that used a series of article characteristics to determine the field of papers published in multidisciplinary journals. Articles are assigned to a country, or economy on the basis of the institutional addresses of the authors listed in the article. Articles are credited on a whole count basis (i.e., for articles produced by authors from different countries, each country is credited for one article). The percentages refer to the proportion of AI articles to feature collaboration. Data for all regions, countries, and economies are available in supplemental table SPBS-99 in Publications Output: U.S. Trends and International Comparisons (https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-99).

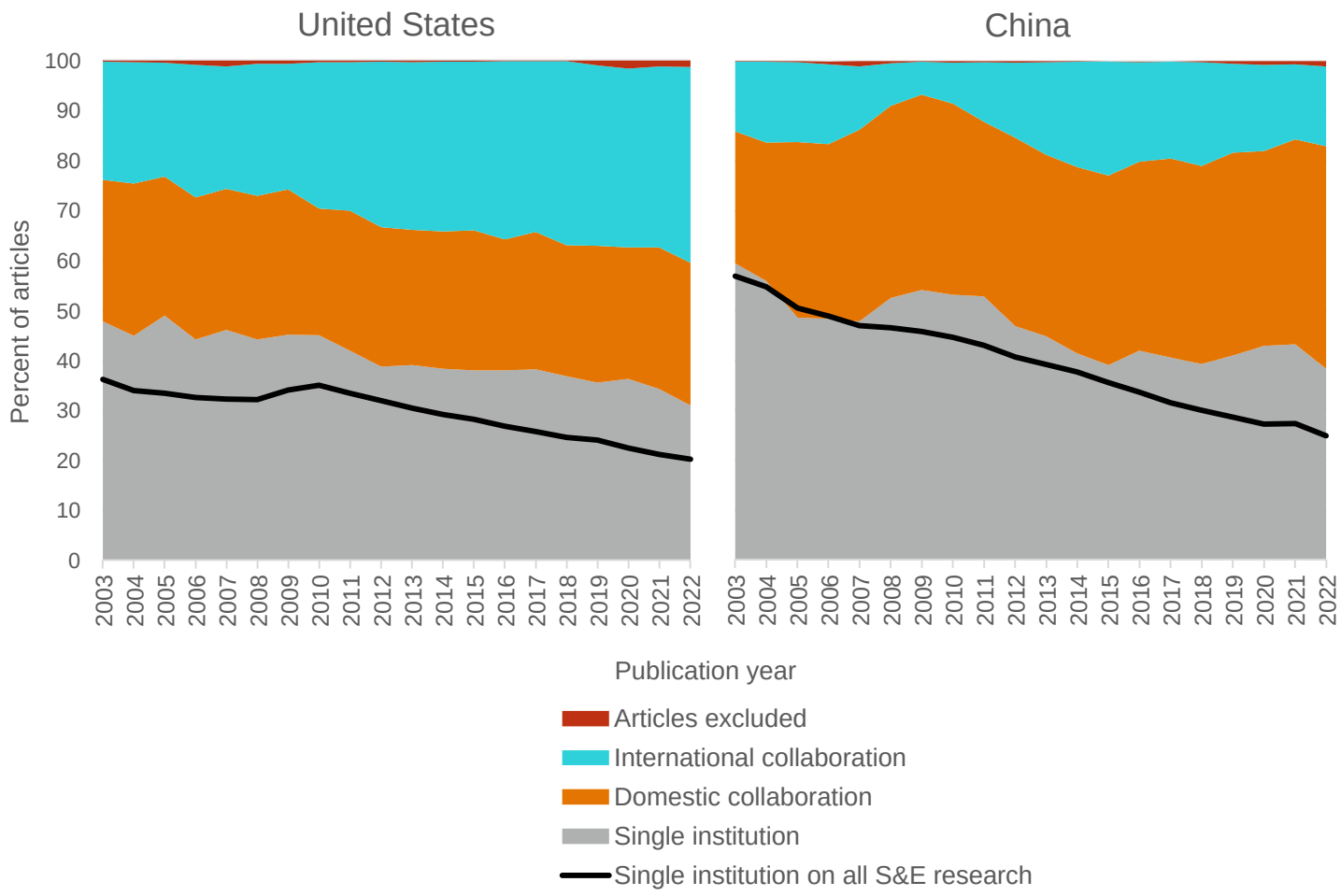
Source(s):
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed April 2023.

Domestic Collaborations and Single Institution Publications

The proportion of single institution publications in AI decreased over time in the United States, from 48% in 2003 to 31% in 2022 (figure 4). Despite this decrease, the proportion of U.S. single institution publications remained higher in AI research than in all S&E research, which decreased from 36% to 20% over the same time period. Over time, the rate of domestic collaboration in AI between U.S. institutions remained relatively stable from 2003 to 2022, ranging between 25% and 30%. In China, the proportion of single institution publications in AI decreased from 59% to 38% between 2003 and 2022, albeit with more fluctuation. China's proportion of single institution publications both in AI papers and among all S&E fields were similar until 2007, after which the proportion of single institution papers in AI research became higher, while the overall proportion of single institution papers in all S&E research continued to decrease.

Figure 4

Collaborative and single institution articles on AI and single institution articles on all S&E research in the United States and China: 2003–22



AI = artificial intelligence; S&E = science and engineering.

Note(s):
Article counts refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. The subset of AI articles was determined by All Science Journal Classification subject matter classification, supplemented by an algorithm that used a series of article characteristics to determine the field of papers published in multidisciplinary journals. Articles are assigned to a country, or economy on the basis of the institutional addresses of the authors listed in the article. Articles are credited on a whole count basis (i.e., for articles produced by authors from different countries, each country is credited for one article). The percentages refer to the proportion of AI articles to feature collaboration or to the proportion of general articles across all fields to feature collaboration. Articles were excluded when one or more coauthored

publications had incomplete address information in the Scopus database; therefore, they cannot be reliably identified as international or domestic collaborations. Data for all regions, countries, and economies are available in supplemental table SPBS-99 and supplemental table SPBS-33 in Publications Output: U.S. Trends and International Comparisons (https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-99 and https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-33).

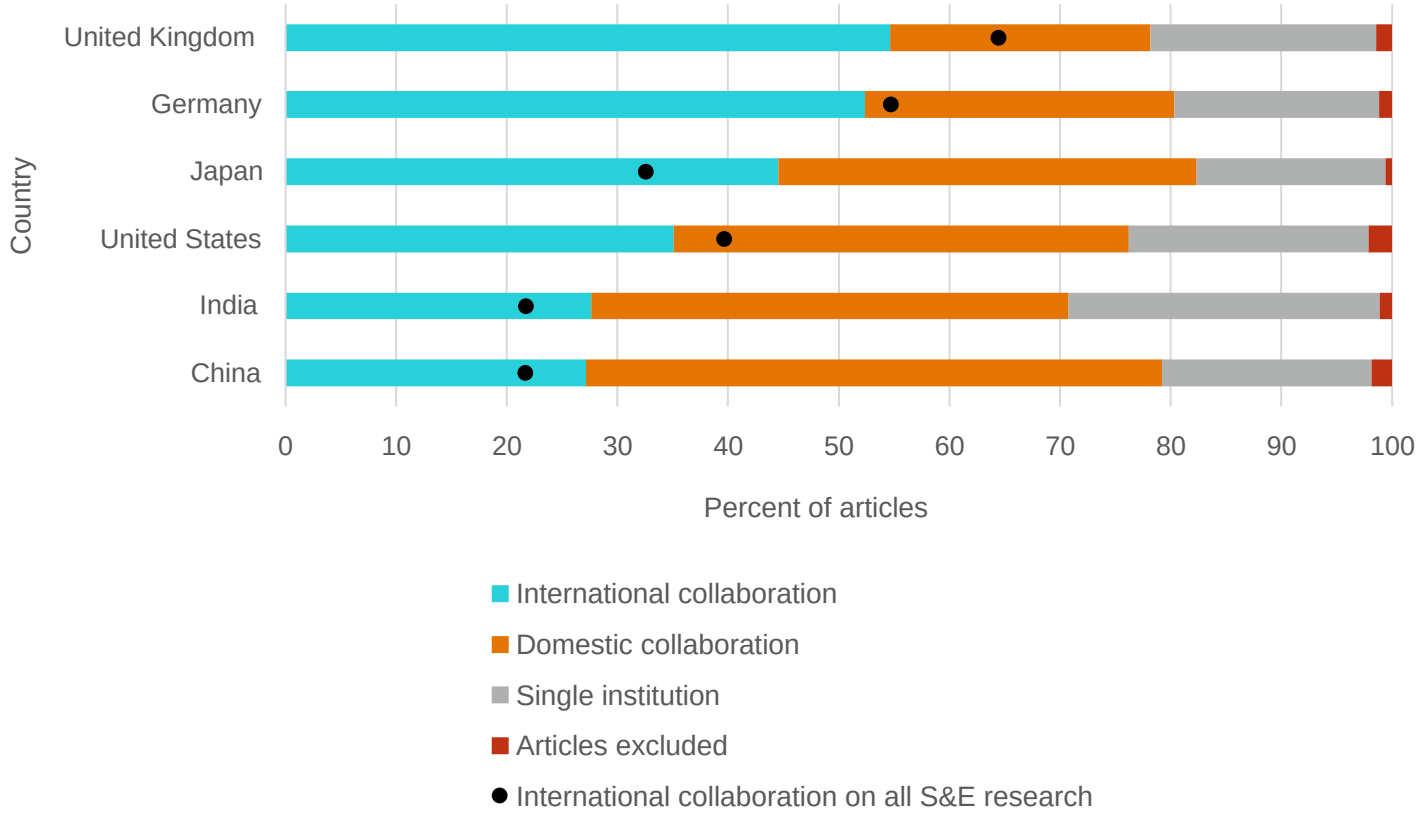
Source(s):
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed April 2023.

COVID-19 Research Collaboration

In 2020, COVID-19 was identified as a national priority (https://www.whitehouse.gov/priorities/), and this shifting priority in research may have impacted collaboration patterns for this research area in 2020. In the same year, 35% of the United States' published research on COVID-19 involved international collaborations, which was lower than the rates in the United Kingdom (55%), Germany (52%), and Japan (45%) but was higher than the rates in China (27%) and India (28%) (figure 5). The overall rates of international collaboration in the United Kingdom and Germany were higher for all S&E research than for COVID-19 research (65% and 55%, respectively).

Figure 5

International collaboration, domestic collaboration, and single institution publications on COVID-19 research and overall international collaboration on all S&E research, by selected country: 2020



S&E = science and engineering.

Note(s):
Article counts refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. Articles are assigned to a country, or economy on the basis of the institutional addresses of the authors listed in the article. Articles are credited on a whole count basis (i.e., for articles produced by authors from different countries, each country is credited for one article). The percents refer to the proportion of COVID-19 articles to feature collaboration or to the proportion of general articles across all fields to feature collaboration. Articles

were excluded when one or more coauthored publications had incomplete address information in the Scopus database; therefore, they cannot be reliably identified as international or domestic collaborations. Data for all regions, countries, and economies are available in supplemental table SPBS-91 and supplemental table SPBS-35 in Publications Output: U.S. Trends and International Comparisons (https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-91 and https://ncses.nsf.gov/pubs/nsb202333/table/SPBS-35).

Source(s):
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed April 2021.

Although each of the top producing countries had a lower rate of international collaborations in AI research than in S&E research, the results were mixed for COVID-19. As the number of articles in AI has increased, the rate of international collaboration also increased. For COVID-19 collaborations in 2020, only some of the top producing countries had lower rates of international collaboration in AI research than in all S&E research.

Data Sources, Limitations, and Availability

Publication data are derived from a large database of publication records that were developed for *Science and Engineering Indicators 2024,* Publications Output: U.S. Trends and International Comparisons (NSB-2023-33), from the Scopus database by Elsevier. The publication counts and coauthorship information presented are derived from information about research articles and conference papers (hereafter referred to collectively as articles) published in conference proceedings and peer-reviewed scientific and technical journals. Elsevier selects journals and conference proceedings for the Scopus database based on evaluation by an international group of subject-matter experts (see NSB-2023-33, Technical Appendix), and the National Center for Science and Engineering Statistics (NCSES) undertakes additional filtering of the Scopus data to ensure that the statistics presented in *Science and Engineering Indicators* measure original and high-quality research publications (Science-Metrix 2023). Although the listed affiliation is generally reflective of the locations where research was conducted, authors may have honorary affiliations, have moved, or have experienced other circumstances preventing their affiliations from being an exact corollary to the research environment.

The subset of AI articles was determined by All Science Journal Classification subject matter classification. Global coronavirus publication output data for 2020 were extracted from two different sources. The COVID-19 Open Research Dataset (CORD-19) was created through a partnership between the Office of Science and Technology Policy, the Allen Institute for Artificial Intelligence, the Chan Zuckerberg Initiative, Microsoft Research, Kaggle, and the National Library of Medicine at the National Institutes of Health, coordinated by Georgetown University's Center for Security and Emerging Technology. CORD-19 is a highly inclusive, noncurated database. The other coronavirus publication output data source was the Scopus database, which permits more refined analysis because it includes more fields (e.g., instructional country of each author). (See NSB-2021-4, Technical Appendix).

Notes

1 See table SPBS-22 in National Science Board, National Science Foundation. 2023. Publications Output: U.S. Trends and International Comparisons. *Science and Engineering Indicators 2024.* NSB-2023-33. Available at https://ncses.nsf.gov/pubs/nsb202333.

2 See NSB-2023-33, table SPBS-99.

3 See NSB-2023-33, figure PBS-3.

4 See NSB-2023-33, table SPBS-22.

5 See NSB-2023-33, figure PBS-3.

References

Carvalho DS, Felipe LL, Albuquerque PC, Zicker F, Fonseca BDP. 2023. Leadership and International Collaboration on COVID-19 Research: Reducing the North–South Divide? *Scientometrics* 128:4689–705. Available at https://doi.org/10.1007/s11192-023-04754-x.

Chinchilla-Rodríguez Z, Sugimoto CR, Larivière V. 2019. Follow the Leader: On the Relationship between Leadership and Scholarly Impact in International Collaborations. *PLOS ONE* 14:e0218309. Available at https://doi.org/10.1371/journal.pone.0218309.

Gazni A, Sugimoto CR, Didegah F. 2012. Mapping World Scientific Collaboration: Authors, Institutions, and Countries. *Journal of the American Society for Information Science and Technology* 63:323–35. Available at https://doi.org/10.1002/asi.21688.

Katz JS, Hicks D. 1997. How Much Is a Collaboration Worth? A Calibrated Bibliometric Model. *Scientometrics* 40:541–54. Available at https://doi.org/10.1007/BF02459299.

Lee Y-N, Walsh JP, Wang J. 2015. Creativity in Scientific Teams: Unpacking Novelty and Impact. *Research Policy* 44:684–97. Available at https://doi.org/10.1016/j.respol.2014.10.007.

Leydesdorff L, Wagner CS. 2008. International Collaboration in Science and the Formation of a Core Group. *Journal of Informetrics* 2:317–25. Available at https://doi.org/10.1016/j.joi.2008.07.003.

Science-Metrix. 2023. *Bibliometric Indicators for the Science and Engineering Indicators 2024. Technical Documentation*. Available at https://science-metrix.com/bibliometrics-indicators-for-the-science-and-engineering-indicators-2024-technical-documentation/. Accessed 26 August 2023.

Wagner CS, Brahmakulam IT, Jackson BA, Wong A, Yoda T. 2001. *Science and Technology Collaboration: Building Capacity in Developing Countries?* Santa Monica, CA: RAND Corporation. Available at https://www.rand.org/pubs/monograph_reports/MR1357z0.html.

Wuchty S, Jones BF, Uzzi B. 2007. The Increasing Dominance of Teams in Production of Knowledge. *Science* 316:1036. Available at https://doi.org/10.1126/science.1136099.

Suggested Citation

Boothby C, Schneider B; National Center for Science and Engineering Statistics (NCSES). 2024. *International Collaboration in Selected Critical and Emerging Fields: COVID-19 and Artificial Intelligence.* NSF 24-323. Alexandria, VA: National Science Foundation. Available at https://ncses.nsf.gov/pubs/nsf24323.

Contact Us

Report Authors

Clara Boothby
ORISE Fellow
NCSES
E-mail: cboothby@nsf.gov

Benjamin Schneider
Interdisciplinary Science Analyst
NCSES
Tel: 703.292.8828
E-mail: beschnei@nsf.gov

NCSES

National Center for Science and Engineering Statistics
Directorate for Social, Behavioral and Economic Sciences
National Science Foundation
2415 Eisenhower Avenue, Suite W14200
Alexandria, VA 22314

Tel: (703) 292-8780
FIRS: (800) 877-8339
TDD: (800) 281-8749
E-mail: ncsesweb@nsf.gov