International Research Collaborations on COVID-19 Amidst Geopolitical Tensions with China

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Abstract

As the threat of COVID-19 and US-China tensions are increasing, this study focused on this intensifying intersection between geopolitics and global science in the midst of a pandemic. This scientometric study compared proportions of international S&E collaborations during and before COVID-19 by countries through the lenses of scientific nationalism and scientific globalism. Social network analyses were also conducted to observe the various ties between countries on S&E COVID-19 publications, with a particular focus on China. While scientific nationalism would assume that the current political rhetoric and protectionist policies would lead to a decrease in international collaboration, our findings showed the reverse. The proportion of international collaborations and extent of multilateralism generally increased. Findings also revealed that despite geopolitical tensions and China's recently introduced publication evaluation policy, the US and China remain the world's leading international collaborators, including on S&E COVID-19 research.

Introduction

As scientists in every major region of the world are seeking to address Coronavirus Disease 2019 (COVID-19), global strains are making international cooperation difficult. Based on a survey of experts in geopolitics and technology, more than half indicated geopolitical tensions as among the leading obstacles to a swift global recovery (Scott, 2020). National competition and country-first political agendas have spilled over to scientific research, such as in governmental funding towards national over global research funds (Stevis-Gridneff & Jakes, 2020), warnings about the stealing of COVID-19 research data (National Cyber Security Centre, 2020) and accusations about the intentional spread of misinformation by some countries (Moore, 2020). Such suspicions have not only slowed efforts to identify an effective antiviral treatment, but also to collaborate across borders in addressing future global challenges.

At the center of this geopolitical conflict is the US and China, the two leading scientific knowledge producers of the world and two largest international research collaborators (Nature Index, 2019). Since the new coronavirus was identified, the two countries' trade war has now escalated to a potentially new cold war. As the two superpowers are economically decoupling, some have suggested that COVID-19 exacerbated preexisting leeriness about a possible overreliance on global trade and international supply chains (Johnson & Gramer, 2020). With rising populism and a looming global recession, countries are looking increasingly inwards to address societal problems. Most notably, China has introduced a new reform measure that places greater value on research that directly addresses domestic needs, which is predicted to lead to a notable decline in papers produced in international journals (Petrou, 2020). Based on a study of the US-China research publications pre-pandemic, the co-authorship rate had been steadily rising but was supported mostly by China (AuthorsLee & Haupt, 2019). With China's changing research evaluation standards, a smaller proportion of internationally collaborated studies is likely but what this means in the midst of a global health crisis was the purpose of the study. As COVID-19 and international tensions are reaching unprecedented heights and increasing, this study examined this strained junction between geopolitics and global science, with a particular focus on China.

US-China Research Competition and Collaboration

The US and China account for almost half of the world's research and development (R&D) expenditures and the following top countries account for over a third of the global total: Japan, Germany, South Korea, France, India, United Kingdom, Russia, Brazil, Taiwan, Italy, Canada, Spain, Turkey, and Australia (National Science Foundation, 2019). In terms of productivity,

China bypassed the US's top position in science and engineering publications during 2017. China's fast rise in just a decade was twice as fast as the world's average (NSF, 2019). The US maintains the world's lead in scholarly impact (i.e., top 1% of articles cited) but China's citation measure is increasing (NSF, 2018) and expected to overtake the US's lead position by 2022 (Baker, 2018). This trend reflects similar patterns based on a country's level of economic development. Whereas upper-middle income countries' publication rates have been steadily rising (9% increase per year), high income countries have mostly flattened (1% increase per year) (NSF, 2019). Research and development (R&D) spending reflect similar patterns. US R&D spending grew 4.3% per year while China's grew 17% per year (NSF, 2018) and preliminary 2019 data suggests China has recently surpassed the US in R&D spending (Viglione, 2020). In comparing the relative contributions among US-China publications, China leads in both funding these bilateral research studies as well as in authorship (Lee & Haupt, 2019).

All countries have benefited from international research collaboration, not only to increase their measure of national scientific output, but also their impact on the broader scholarly fields. In comparison to domestic publications, internationally coauthored publications tend to have a higher number of citations (Adams, 2013; Chinchilla-Rodríguezа, Vargas-Quesadab, Hassan-Monterob, González-Molinab, & Moya-Anegóna, 2010; Leta & Chaimovichpuuska, 2002; Smith, Weinberger, Bruna, & Allesina, 2014) given the wider range of scholarly expertise, higher standards, and greater resources (Georghiou, 1998), leading to wider specialized networks and a larger audience (Sun, Kaur, Milojevic, Flammini, & Menczer, 2013). For such reasons, international co-authored publications have been steadily increasing and now comprise about one out of five research articles (NSF, 2019). Although the US and China are at the forefront of scientific knowledge production and collaboration, their proportion of internationally authored works are less than their domestic output (39%, 21%, respectively) (NSF, 2019). Countries with noticeably higher rates of international collaboration include the UK (62%), Australia (60%), France (59%), Canada (56%), Germany (53%), Spain (53%), and Italy (50%) (NSF, 2019). Yet among all countries, the highest number of internationally collaborated articles involve the US and China (Nature Index, 2019).

Global science also benefits when international researchers collaborate. Nation-states have long engaged in "science diplomacy" by addressing global concerns via science in cooperation, while also negotiating for their domestic interests, such as improving their domestic skills and capabilities (Kaltofen & Acuto, 2018; Linkov, et al., 2016). The U.S.-China Agreement on Cooperation in Science and Technology (the S&T Agreement) since 1979 and renewed during 2011, supported thousands of US-China cooperative programs across 50 interagency agreements with federal agencies (US Department of State, 2012). Global concerns, such as pandemic outbreak prevention and control, wildlife management and conservation practices, renewable energy and efficiency, and other global goods have been addressed through these bilateral research agreements. For both SARS and the Ebola outbreak, international collaboration was high, with China leading SARS publications and the US leading Ebola publications (Sweileh, 2017). Clearly, international cooperation involving these two superpowers can help eradicate COVID-19, but political realities also shape the extent to which and how scientific collaboration occurs. As of the writing of

this study, the status of the S&T Agreement has not been determined as international relations worsen. Over the past two years especially, the US has proposed numerous polices on limiting scientific engagement specifically with China, such as denying visas to Chinese citizens (Yoon-Hendricks, 2018; US White House, 2020), banning Chinese funding sources (Sharma, 2019), and developing protocols to monitor Chinese students and scholars (Feng, 2019).

COVID-19 and Geopolitical Tensions

While scientists throughout the world are still scrambling to understand and address COVID-19, geopolitical strains continue to escalate. Nations are disputing the source of the new coronavirus and the extent to which information is being shared. While US leaders have referred to COVID-19 as the “Chinese Virus” or “Wuhan Virus,” Chinese leaders have blamed the US Army for allegedly bringing the virus to Wuhan (Crowley, Wong, & Jakes, 2020). An international call, initially led by Australia and with early support from the US, UK and France, to investigate COVID-19’s origins has fueled tensions with China (Mercer, 2020). There have also been questions about intellectual theft as the US and UK warned against malicious cyber activity, including sensitive data on COVID-19 related research (National Cyber Security Centre, 2020). The US has been more explicit about the country’s suspicions about China as the Director of the National Counterintelligence and Security Center expressed, “we have full expectation that China will do everything in their power to obtain any viable research that we are conducting here in the U.S.” (Myre, 2020, para. 7). US policymakers have described coordination with China as “a self-harming exercise in a zero-sum competition for global leadership” (Hass & Doug, 2020, para 3). A chief virologist expert at China’s Center for Disease Control and Prevention (China CDC), Shao Yiming, rejected outside criticism and accused the US of being less open than China, pointing to US’ withdrawal from the China CDC after almost 20 years (Cohen, 2020). The World Health Organization (WHO) has also suffered from US-China tensions as US President Trump accused the organization of espousing a pro-China bias and threatened to permanently cut its funding (Restuccia, Lubold, & Hinshaw, 2020). As the pandemic continues to take hundreds of thousands of lives, the US and China are edging into a “new cold war.”

Meanwhile, the sharing of COVID-19 study findings based in China may be stalled. During April 2020, the Chinese Academy of Sciences issued the notice that any COVID-19-related research publications will be subjected to additional scrutiny for “academic value” and “timing” and must be approved by the government prior to public release (Gan, Hu, & Watson, 2020). The public announcement has since been removed and its enforcement is unclear, but this possible added review raised immediate international worries about future international collaboration with China (Sharma, 2020). Such so-called “highly political” steps taken by the Chinese government, has international scientists concerned about the sharing of data and the extent to which international collaboration might be hindered in the future (Sharma, 2020, para 40). Despite these hurdles, President Xi defended the country as having transparently shared information to the WHO since the outbreak began and assured the World Health Assembly that the "COVID-19 vaccine development and deployment in China, when available, will be made a global public good” (Wheaton, 2020, para 3).

China’s Research Evaluation Reform

Perhaps the biggest shift that will impact the future of international scientific collaboration is China’s newly reformed researcher-evaluation system, which was announced in the midst of the global pandemic. During February 2020, China’s Ministry of Education and Ministry of Science and Technology issued a joint announcement to halt any promotion or recruitment on the sole basis of the number of publications or citations, as well as any publishing bonuses, and is in the process of identifying new indicators that include more direct application to societal problems (Nature, 2020). This effort would allow scientific research to more directly address China’s concerns within China’s context (Huang, 2020). This measure was part of a broader initiative for scientific reform in China that included streamlining researcher and research institute evaluations, (State Council, PRC, 2018a), improving scientific integrity (State Council, PRC, 2018b) and focusing on science that would improve the national economy (State Council, PRC, 2018c). Additional policies towards further reform are anticipated (Yan, 2020).

This latest researcher evaluation policy especially received international attention because it ultimately places greater emphasis on non-Science Citation Index (SCI) journals, particularly domestic journals based in China. The new policy’s preference for “quality” over the number of publications or the journal impact factor is expected to lead to a significant decline in the total number of Chinese publications in English-language journals and increase in domestic Chinese journals (Tao, 2020). Based on an analysis of 2018 Web of Science and other data sources, Petrou (2020) suggests as much as 75,000 papers, or 3.5% of all articles and reviews would absent from SCI journals in the next 2-3 years. China’s reform may have a negative effect on international collaboration as well for several reasons. Besides China’s being the largest producer of scientific research, future international collaboration (and consequently global impact) may be hindered by language, the lack of incentives for non-Chinese to publish in Chinese journals, and a research priority in addressing China first that may not align with the interests of outside scholars.

China’s reform more broadly challenges a global system that has long been dominated by the West (i.e., Anglo America and Western Europe). Given the unusually powerful role of China in the world’s scientific research production, China’s steps reform measures could potentially change the long-dominated Western core of global science. Calls to cease China’s “SCI worship” began as early as 2016, stemming from domestic worries about the country’s hyperfocus on quantitative Science Citation Index (SCI) indicators over societal value (Zhang & Siversten, 2020). This move was partly in response to a more globally shared concern about governmental and university funds being used towards international publishers, mostly based in Western Europe and the US, and then paying them again to access their own scientific articles at full price (Schiermeier, 2018). Lower income countries tend to be even more on the scientific “periphery” due to the unaffordability of journal subscriptions (Chan, Kirsop, and Arunachalam, 2011).

Besides the issue of costs, scholars have criticized the hegemonic discourses dominated by and reinforced in Anglophone journals, even in the science fields (Passi, 2005; Meriläinen, Tienari, Thomas, & Davies, 2008). China also expressed opposition to the “blind pursuit of rankings” and an overreliance on “papers only, professional titles only, academic qualifications only, or awards only,” in favor of a more holistic review to assess quality (Yan, 2020, p. 2). Indeed, past research has found that universities throughout the world are building legitimacy via external criteria (i.e., global rankings metrics), particularly among those at the highest ranks (Stensaker et al, 2019). A related study further found that this pursuit towards global status can come at the cost of local needs (AuthorsLee, Vance, Stensaker, & Ghosh, 2020). For countries that are located outside the West, the domestic payoffs are likely greater. For these reasons, China’s reform

has been framed as offering more direct benefit to Chinese society but, as Zhang and Siversten (2020) note, China intends to balance both international and domestic agendas. The extent to which both are possible, is the framework for this study.

Conceptual Framework

Much of the political rhetoric and domestic-oriented policies discussed above can be framed as representations of scientific nationalism, which essentially views scientific research as a means to primarily advance the nation-state. Based on this zero-sum view, one would expect that COVID-19 research may increase overall, but that international collaboration would decline. Indeed, numerous prominent news outlets have suggested US-China conflicts are occurring at the expense of international cooperation and ultimately, addressing COVID-19 (e.g., Crowley, Wong & Jakes, 2020; Gan, Hu, & Watson; 2020; Johnson & Gramer, 2020; Nature, 2020).

However, some scholars have theorized that scientific nationalism does not have to impede the advancement of international cooperation in science. According to Sá and Sabzalieva (2018), scientific globalism can be understood as "a global endeavour with norms deriving from the scientific community, cutting across political, ethnic and cultural borders" (p. 151). This "emerging geography of scientific knowledge and collaboration" (Peters, 2006, p. 226) aims toward the advancement of knowledge and open science for all of human society (Sá and Sabzalieva, 2018), which can be contrasted to scientific nationalism's focus on economic competitiveness and nation-building. Thus, while scientific globalism can be conceptually disentangled from the narrower concept of scientific nationalism, they are, in reality, highly intertwined (Sá and Sabzalieva, 2018; Cantwell & Grimm, 2018; Lee & Haupt, 2019). In some ways, the two can also be highly synergistic and countries are able to pursue both simultaneously. Marginson (2018) attributes China's rising success to its "national/global synergy" based on the ways that the country's national policies tapped into the global science system. In a study of co-publications between the US and China over the past five years, Lee and Haupt (2019) also found that scientific research can be both national and global pursuits as a positive sum endeavor. From a scientific nationalism view, the authors found that despite US attempts to curb international research engagement with China, the US benefits from China's contribution to US research productivity. From a scientific globalism lens, global science is simultaneously advanced as demonstrated by the two countries' increasing output of co-authored scientific papers, at least prior to COVID-19 and China's recently reformed publication evaluation policy.

In essence, scientific globalism (as well as scientific nationalism) will endure as long as there is international collaboration in research, but the concepts are not interchangeable. International research participation is uneven and will always be at least somewhat shaped by national, multinational, and commercial interests. Based on their social network analysis of global science, Wagner and Leydesdorff (2005) found that the global research network is self-organizing, without any central authority directing science and that national interests alone do not explain the extent of international linkages being created. That is, international collaboration networks are "growing independently of and orthogonally to national systems of science. The national systems continue to operate, but they are affected by the emerging global system" (p. 205). In sum, scientific globalism further assumes that global networks exist outside of national systems and thus collaboration can transcend domestic agendas and policies.

Methods

This study sought to examine the extent of international science and engineering (S&E) research collaboration on COVID-19, with a particular focus on China given the surrounding geopolitical climate and the country's recently changed publication evaluation policy. This focused analysis on China followed a broader study that examined the effects of national wealth and pandemic impact on international collaboration and open access publication patterns on COVID-19 across all fields and countries (Under Review).

The study was based on scientometrics, a subfield of bibliometrics, utilizing statistical methods to analyze scientific publications. Bibliometrics is commonly used to systematically examine research collaborations given the limitations of surveys and observations (Subramanyan, 1982). The data for this scientometric study was collected using Scopus (Elsevier, 2020), and strictly based on "articles," which Scopus defines as "original research or opinion," most commonly found in peer-reviewed journals (Elsevier, 2017, p. 10), in the SE fields.

Two datasets were created and compared: a) S&E article publications from January 1, 2015 to December 31, 2019 and b) COVID-19 S&E article publications from January 1, 2020 to May 25, 2020. The latter dataset was based on the inclusion of articles containing at least one of the following phrases,"COVID-19," "2019-ncov, "sars-cov-2," and "novel coronavirus," in the title, abstract, and key words fields during this time frame. January 1, 2020 was selected as the starting point that soon led up to COVID-19 being declared as a pandemic by the World Health Organization (WHO). Based on the WHO (2020) timeline, on December 31, 2019, a novel coronavirus was identified, as the Wuhan Municipal Health Commission in China, reported a cluster of pneumonia cases in Wuhan, Hubei Province. Since that date, COVID-19 quickly accelerated and was declared a pandemic on March 11, 2020. At the time of writing this study, June 2020, scientists are still learning about this virus and how to best contain it.

For both data sets, country specific publication information was downloaded from Scopus for all countries with at least one publication. This information included a country's total number of S&E publications, a country's total number of collaborations with all other countries in the data sets, and a country's total number of publications with domestic only affiliations. The latter measure was obtained for each country by excluding all other countries in the Scopus advanced search window. Articles were assigned to countries on a full count basis, so that an article was counted toward each co-authoring country's total number of publications.

Three measures were calculated to compare the 2015-2019 and COVID-19 2020 data sets. First, the number and percentage of international collaborations and were calculated and statistically compared. The number of international collaborations was obtained by subtracting a country's total number of S&E publications by its total number of publications with domestic only affiliations. A chi-square test of independence were performed to compare the percentage

of international collaborations for the 2015-2019 and COVID-19 data. The same test was also applied to each of the top 25 COVID-19 research producing countries. Second, the number and percentage of China's international collaborations with the top 25 COVID-19 research producing countries were calculated and compared. Third, to provide insight into the identified trends in collaboration, the average number of ties to different countries per article was calculated and statistically compared for the top 25 COVID-19 research producing countries. This measure was calculated by summing the total number of ties to other countries that a given country had for both the 2015-2019 and COVID-19 2020, and then dividing the number of ties by the total number of international collaborations during the time periods. The average number of ties to different countries per article provides insight into whether a country has maintained or increased ties with other countries even though its proportion of articles that involve international collaborations has declined. In other words, a country may collaborate with other countries more often but on a fewer number of articles.

Finally, an analysis was conducted to provide further insight into the total number of ties between all countries as well as strength of ties between countries for COVID-19 2020 research. Utilizing the COVID-19 2020 data set, a valued adjacency matrix was constructed in UCINET (Borgatti, Everett, & Freeman, 2002). Univariate descriptive statistics were calculated to determine the total sum of all ties between countries. Additionally, two network maps were constructed in NetDraw (Borgatti, 2002): a network map including all countries that published at least one article related to COVID-19 and an ego-network map of China's COVID-19 collaboration network. The maps were built utilizing Netdraw's multidimensional scaling and ordination tool. This tool constructs network maps that position nodes closer to one another if they are strongly connected, or have collaborated more, and position nodes farther apart if they are weakly connected, or have collaborated less (Borgatti, Everett, & Johnson, 2013). To further visualize strength of ties, the lines connecting countries were weighted with thicker lines representing countries that collaborated more and thinner lines representing countries that collaborated less.

Findings

122 countries published at least one S&E article on COVID-19 as of May 25, 2020, and 93%, or 114, of these countries had at least one international collaboration. The total sum of all ties between countries was 9,540. As shown in Figure 1, the United States, China, the UK, Italy, Canada, Germany, Spain, Australia, Netherlands, Switzerland, and France had high levels of collaboration with one another on COVID-19 research. China and the US collaborated more than any two countries with a total of 122 publications that included both countries' authors. The next highest collaboration rates were between the US and Canada (71 publications), the US and the UK (70 publications), and the US and Italy (65 publications). Furthermore, these 11 countries were the most engaged in international collaboration with each country having at least 300 ties to other countries. The US had the most ties with a total of 867, while the UK and Italy had the second and third highest number of ties, 656 and 624, respectively.

Findings further indicate global science intensifies during a global crisis, even despite international tensions and initial attempts towards national reform. As shown in Table 1, the world's proportion of international collaboration on COVID-19 (32%) is higher than recent years, prior to the pandemic (26%). The difference between the two time periods was statistically significant [$\chi^2(1)=100.015$, $p < .001$].

Table 1. Frequencies of single country publications and international publications for S&E articles published between 2015 and 2019 and for S&E articles on COVID-19

Time Period	Total Publications	Total Single Country Publications	% Single Country Publications	Total International Collaborations	% International Collaborations
Publications from 2015-2019	8,184,254	6,090,180	74.41%	2,094,074	25.59%
COVID-19	4,878	3,325	68.16%	1,553	31.84%

Next, in observing the top S&E COVID-19 research producing countries, China led (1350), followed by the US (936), Italy (470), the UK (304), and India (211). However, when examining the proportion of internationally co-authored research among the 25 largest producers, China ranked the lowest on the list, collaborating on less than 19% of its COVID-19 papers. The US was also towards the bottom at about 39%. The countries with the highest percentage of internationally coauthored works were Belgium (80%), Hong Kong (75%), Canada (73%), Sweden (73%), and Saudi Arabia (72%). Yet, these countries were among the lower producers among the top 25, each producing a small fraction of papers compared to the much larger scientific producers, China and the US.

What is perhaps more interesting is the extent to which countries increased or decreased their proportion of internationally collaborated publications when comparing S&E COVID-19 articles to the past. Among the top percentage increases were Japan (25%), Poland (21%), and Canada (14%) while the top percentage decreases were Singapore (-32%), France (-20%), and Switzerland (15%). Both the US and China slightly declined (-5%, -2%, respectively). Each of these particular differences were statistically significant.

Table 2. Frequencies of single country publications and international publications for S&E articles published between 2015 and 2019 and for S&E articles on COVID-19 by top 25 country

Country	Total COVID-19 S&E Publications	% International Collaborations on S&E COVID-19	% International Collaborations on S&E 2015-2019	% Difference	p-value
China	1350	18.96%	21.19%	-2.23%	.045
United States	936	38.78%	44.22%	-5.44%	.001
Italy	470	37.66%	51.81%	-14.15%	.000
United Kingdom	304	61.84%	66.68%	-4.84%	.073
India	211	25.59%	18.51%	7.08%	.008
France	185	42.16%	62.16%	-20.00%	.000
Canada	167	73.05%	58.91%	14.15%	.000
Germany	160	55.00%	57.36%	-2.36%	.547
Spain	155	45.81%	54.47%	-8.66%	.030
Australia	132	69.70%	63.19%	6.51%	.121
Switzerland	122	59.02%	74.15%	-15.14%	.000
Netherlands	98	67.35%	67.24%	0.11%	.982
Singapore	97	38.14%	69.78%	-31.63%	.000
Iran	86	33.72%	21.44%	12.28%	.006
Brazil	83	32.53%	33.74%	-1.21%	.816
South Korea	77	28.57%	28.04%	0.53%	.918
Japan	72	55.56%	30.45%	25.10%	.000
Taiwan	68	35.29%	35.94%	-0.65%	.912
Turkey	57	33.33%	22.96%	10.37%	.063
Belgium	56	80.36%	72.57%	7.78%	.192
Hong Kong	56	75.00%	78.36%	-3.36%	.542
Mexico	55	50.91%	43.22%	7.68%	.250
Saudi Arabia	46	71.74%	78.12%	-6.38%	.295
Sweden	44	72.73%	70.19%	2.54%	.713
Poland	41	56.10%	35.32%	20.78%	.005

Figure 2 shows that among the 25 top S&E COVID-19 research producers, the average number of different country ties ranged from 7.2 per article to 2.1 per article. Most countries tended to collaborate on average with authors from 3 or more different counties on S&E COVID-19 international publications, with the exception of China (2.1), the US (2.4), and Mexico (2.6). This finding indicates that for these three countries, internationally co-authored research tended to be bilateral. Findings also reveal that all top 25 countries except for one (Mexico) increased its average number of different country ties per S&E article on COVID-19 research. Among this group, Turkey had the largest increase, with an average of 3.4 more different country ties per article. China and the US were among the bottom 5 in regard to any change between the two periods. China's average increased from an average of 1.5 outside country ties per article from 2015-2019 to 2.1 on S&E COVID-19 research. The US also slightly increased from an average of 1.7 to 2.4. Overall, the data demonstrate countries have generally increased the number of different countries they collaborate with per article, which helps to explain declines in proportions of international collaborations but increases in the number of collaborating countries, such as in the case of China.

Next, we observed China's S&E collaboration patterns on COVID-19. According to Figure 3, China collaborated with 64 countries on COVID-19 related research. With these countries, China had a total of 545 ties. China collaborated the most with the United States, the UK, Canada, Australia, and Hong Kong, having engaged in least 30 collaborations with each of these countries. However, China's rate of collaboration with the US was substantially higher than with any other country. Chinese scientists collaborated with US scientist 2.7 times more than they did with scientists from the UK, its second highest collaborator.

Next, Table 3 compares China's S&E collaborations during pre-COVID-19 (2015-2019) and COVID-19. Among the top 25 countries, China has either maintained or increased its proportion of international collaboration with each country. Despite current political strains, the US continue to be China's lead international collaborator. Almost half of China's S&E COVID-19 international articles include US authors, and reflects a 5% increase compared to pre-COVID-19. The UK is the second lead collaborator, also showing an increase (9%). The most notable increase per country is Italy (9%), likely reflecting the country's high caseload early in the pandemic.

Table 3. China's international collaborations for S&E articles published between 2015 and 2019 and for S&E articles on COVID-19 with top 25 countries

Country	Total S&E Collaborations with China 2015-2019	% of China's International Collaborations on S&E 2015-2019	Total Collaborations with China on S&E COVID-19	% of China's International Collaborations on S&E COVID-19	% Difference
United States	182,084	42.08%	122	47.66%	5.58%
Italy	10,815	2.50%	29	11.33%	8.83%
United Kingdom	44,087	10.19%	45	17.58%	7.39%
India	7,987	1.85%	12	4.69%	2.84%
France	18,078	4.18%	12	4.69%	0.51%
Canada	30,123	6.96%	33	12.89%	5.93%
Germany	28,925	6.68%	18	7.03%	0.35%
Spain	8,852	2.05%	12	4.69%	2.64%
Australia	40,315	9.32%	32	12.50%	3.18%
Switzerland	7,440	1.72%	12	4.69%	2.97%
Netherlands	9,895	2.29%	10	3.91%	1.62%
Singapore	16,598	3.84%	12	4.69%	0.85%
Iran	3,441	0.80%	2	0.78%	-0.01%
Brazil	4,961	1.15%	2	0.78%	-0.37%
South Korea	15,424	3.56%	10	3.91%	0.34%
Japan	27,944	6.46%	16	6.25%	-0.21%
Taiwan	13,175	3.04%	11	4.30%	1.25%
Turkey	3,455	0.80%	3	1.17%	0.37%
Belgium	5,574	1.29%	7	2.73%	1.45%
Hong Kong	31,706	7.33%	33	12.89%	5.56%
Mexico	2,433	0.56%	3	1.17%	0.61%
Saudi Arabia	7,789	1.80%	9	3.52%	1.72%
Sweden	9,505	2.20%	6	2.34%	0.15%
Poland	4,728	1.09%	3	1.17%	0.08%

Conclusion

This study sought to address how geopolitical tensions and domestically oriented agendas might change the extent of international collaboration during a time of global crisis. When the two global superpowers, who also are the world's leading collaborators, are opting to focus on national interests in the midst of an urgent worldwide crisis, there may be detrimental effects on the world's ability to effectively respond. This research study paid special attention to China because of it is a leading role on S&E publications, including COVID-19 research, as well as its newly introduced research evaluation policy.

Through the lenses of scientific nationalism and scientific globalism, the findings confirm they coexist, but that scientists' individual agency is less bound by scientific nationalism during a period of global crisis. While scientific nationalism would assume that the current political rhetoric and protectionist policies would correspond with a decline in international collaboration, our findings showed the reverse. There is a higher proportion of internationally co-authored S&E papers on COVID-19 than internationally co-authored S&E papers in the past. This result suggests that scientists are not curbed by scientific nationalism as international collaboration continues and even grows. Scientific globalism may have been accelerated due to the urgent global need for a vaccine and to address future prevention.

Also contrary to expectations, China has maintained its proportion of internationally authored output and despite ongoing political conflicts between the two country leaders, the US continues to be China's lead international collaborator. There is also a general trend across countries towards engaging more internationally on S&E COVID-19 research articles than prior to the pandemic. As demonstrated by these findings, countries can pursue both scientific nationalism and scientific globalism at the same time, as global research networks organize beyond national interests. Thus, while countries are adopting policies that are oriented toward scientific nationalism, scientists still engage highly in scientific globalism via international collaboration. Put another way, international research collaborations are not determined by national policies alone, but also by the extent to which scientists respond. Past research has demonstrated the strong role of individual agency, including person-level factors such as intrinsic motivations (Kato & Ando, 2016), social capital (Melkers & Kiopa, 2010) and migration (Jonkers & Cruz-Castro, 2013). Choosing with whom to collaborate is a highly individualized choice that although the data for this study does not directly address, it does reflect country preferences. Scientists' international networks, and in part global science, are not completely determined by national political agendas but are at least still shaped by the resources and opportunities different countries provide. In most countries, internationalization is also part of a national agenda. In the case of US-China co-authorships, scientists in the two countries have rich scientific environments that support their bilateral collaboration (Kato & Ando, 2016), which helps to explain how scientific globalism patterns are sustained, even despite the geopolitical rivalry.

While international conflicts may not have stopped scientists from working across borders, what remains unknown is the extent to which more international research could have been conducted if there was less international strain. Findings indicate that other countries are engaging with S&E COVID-19 research, even more internationally than the US and China, as demonstrated in the higher proportion of international collaboration (Japan, Poland, and Canada) and more multilaterally, as demonstrated by the higher increase of different country authors per article (Turkey, South Korea, and Japan). It may also be that despite China's newly introduced publication evaluation policy, sweeping changes have not noticeably taken effect yet. China has not decreased its proportion of international collaboration with any of the top 25 countries. It may be that it is too soon to tell, or that Chinese scientists are opting to align with more global

publication standards. Meanwhile, geopolitical tensions between the US and China will unlikely pass as quickly and the fate of the research relationship between the two countries' in the long run is uncertain. With the US and China's tendencies towards bilateral versus multilateral research projects and decline in their respective proportions of international research papers, the rest of the world might be engaging more globally while the two countries continue to look more inwardly. China's move towards re-centering notions of scientific quality beyond SCI indicators is one such step while its long-term impact in the field will be clearer in the years to come. Regardless, the shape of global science is changing but scientific globalism is certainly not going away.

Declarations

The authors declare no competing interests.

References

Adams, J. (2013). The fourth age of research. *Nature, 497*, 557-560.

Baker, S. (2018, July 12). China could overtake US on research impact by mid-2020s. *Times Higher Education*.https://www.timeshighereducation.com/news/china-could-overtake-us-research-impact-mid-2020s

Borgatti, S.P., Everett, M.G., & Johnson, J.C. (2013). *Analyzing social networks*. Thousand Oaks, Calif: SAGE Publications.

Borgatti, S.P. (2002). Netdraw Network Visualization. Harvard, MA; Analytic Technologies.

Borgatti, S.P., Everett, M.G., Freeman, L.C. (2002). Ucinet 6 for Windows. Software for Social Network Analysis. Harvard, MA: Analytic Technologies.

Cantwell, B. & Grimm, A. (2018). The geopolitics of academic science. In B. Cantwell, H. Coates, & R. King (eds.). *Handbook on the Politics of Higher Education* (pp. 130-148). UK: Edward Elgar Publishing.

Chan, L., Kirsop, B., & Arunachalam, S. (2005). Open access archiving: The fast track to building research capacity in developing countries. *Science Development Network*. https://www.scidev.net/global/communication/feature/open-access-archiving-the-fast-track-to-building-r.html

Chinchilla-Rodríguez, Z., Vargas-Quesadab, B., Hassan-Monterob, Y., González-Molinab, A.,

& Moya-Anegóna, F. (2009). New Approach to the Visualization of International Scientific Collaboration. *Information Visualization, 9*, 277–287

Cohen, J. (2020, May 22). 'The house was on fire.' Top Chinese virologist on how China and U.S. have met the pandemic. Science. https://www.sciencemag.org/news/2020/05/house-was-fire-top-chinese-virologist-how-china-and-us-have-met-pandemic?utm_campaign=news_weekly_2020-05-22&et_rid=79816561&et_cid=3336810

Crowley, M., Wong, E., & Jakes, L. (2020, March 22). Coronavirus Drives the U.S. and China Deeper Into Global Power Struggle. *New York Times.* https://www.nytimes.com/2020/03/22/us/politics/coronavirus-us-china.html

Elsevier. (2020). *Scopus.* Retrieved from https://www.elsevier.com/solutions/scopus

Elsevier. (2017). Scopus Content Coverage Guide. Retrieved from https://www.elsevier.com/__data/assets/pdf_file/0007/69451/0597-Scopus-Content-Coverage-Guide-US-LETTER-v4-HI-singles-no-ticks.pdf

Feng, E. (2019, June 28). FBI Urges Universities to Monitor Some Chinese Students and Scholars in The U.S. National Public Radio. Retrieved from https://www.npr.org/2019/06/28/728659124/fbi-urges-universities-to-monitor-some-chinese-students-and-scholars-in-the-u-s

Gan, N., Hu,C., & Watson, I. (2020, April 16). Beijing tightens grip over coronavirus research, amid US-China row on virus origin. CNN. https://edition.cnn.com/2020/04/12/asia/china-coronavirus-research-restrictions-intl-hnk/index.html

Georghiou, L. (1998). Global cooperation in research. *Research Policy, 27*(6), 611-626.

Hass, R. & Doug, K. (2020, April 1). The US, China, and Asia after the pandemic: More, not less, tension. *Brookings.* https://www.brookings.edu/blog/order-from-chaos/2020/04/01/the-us-china-and-asia-after-the-pandemic-more-not-less-tension/

Huang, F. (2020, February 26). China is choosing its own path on academic evaluation. *University World News.* https://www.universityworldnews.com/post.php?story=20200226122508451

Johnson, K. & Gramer, R. (2020, May). The Great Decoupling. *Foreign Policy.* https://foreignpolicy.com/2020/05/14/china-us-pandemic-economy-tensions-trump-coronavirus-covid-new-cold-war-economics-the-great-decoupling/

Jonkers, K. & Cruz-Castro, L. (2013). Research upon return: The effect of international mobility on scientific ties, production and impact. *Research Policy, 42*: 1366-1377.

Kaltofen, C., & Acuto, M. (2018). Science diplomacy: introduction to a boundary problem. *Global Policy*, *9*, 8-14.

Kato M. & Ando, A. (2016). National ties of international scientific collaboration and researcher mobility found in Nature and Science. Scientometrics, 110: 673-694.

Leta, J. & Chaimovich, H. (2002). Recognition and international collaboration:the Brazilian case. *Scientometrics, 53,* 325–335

Lee, J. & Haupt, J.P. (2019). Winners and Losers in US-China Scientific Research Collaborations. *Higher Education.* https://doi.org/10.1007/s10734-019-00464-7

Lee, J.J., Vance, H., Stensaker, B., & Ghosh, S. (2020). Global rankings at a local cost? The strategic pursuit of status and the third mission. Comparative Education, DOI: 10.1080/03050068.2020.1741195

Linkov, I., Basu, S., Fisher, C., Jackson, N., Jones, A. C., Kuklja, M. M., & Trump, B. D. (2016). Diplomacy for science: strategies to promote international collaboration. *Environment Systems and Decisions*, *36*(4), 331-334.

Marginson, S. (2018). National/Global Synergy in the Development of Higher Education and Science in China since 1978. *Frontiers of Education in China, 13*, 486–512.

Melkers, J. and Kiopa, A. (2010), The Social Capital of Global Ties in Science: The Added Value of International Collaboration. *Review of Policy Research, 27*: 389-414

Mercer, P. (2020, April 30). Australia-China Tensions Over Call for Global COVID-19 Probe. *Voice of America.* https://www.voanews.com/covid-19-pandemic/australia-china-tensions-over-call-global-covid-19-probe

Meriläinen, S., Tienari, J., Thomas, R., & Davies, A. (2008). Hegemonic academic practices: Experiences of publishing from the periphery. *Organization*, *15*(4), 584-597.

Moore, M. (2020, May 11). FBI to warn of Chinese hackers trying to steal coronavirus vaccine data. *New York Post*. https://nypost.com/2020/05/11/fbi-to-warn-of-hackers-trying-to-steal-coronavirus-vaccine-data/

Myre, G. (2020, May 11). U.S. Officials: Beware Of China And Others Trying To Steal COVID-19 Research. *National Public Radio*. https://www.npr.org/2020/05/11/853696802/u-s-officials-beware-of-china-and-others-trying-to-steal-covid-19-research

National Cyber Security Centre (2020, May 5). *Advisory: APT groups target healthcare and essential services.* https://www.ncsc.gov.uk/files/Joint%20NCSC%20and%20CISA%20Advisory%20APT%20groups%20target%20healthcare%20and%20essential%20services.pdf

National Science Foundation (2019). *Publications Output: U.S. Trends and International Comparisons.* National Science Board: Science and Engineering Indicators. https://ncses.nsf.gov/pubs/nsb20206/executive-summary

National Science Foundation (2018). *Science and Engineering Indicators 2018*. NSF. https://www.nsf.gov/statistics/2018/nsb20181/report.

Nature. (2020, March 5). China changes tack: A new researcher-evaluation system must not reduce international collaborations. [Editorial] *Nature*, vol 579, p.8.

Nature Index (2019). *Connected World: Patterns of International Collaboration Captured by the Nature Index*. https://www.natureindex.com/country-outputs/collaboration-graph

Paasi, A. (2005). Globalisation, academic capitalism, and the uneven geographies of international journal publishing spaces. *Environment and Planning A*, *37*(5), 769-789.

Peters, M.A. (2006), The Rise of Global Science and the Emerging Political Economy of International Research Collaborations1. *European Journal of Education*, 41: 225-244.

Petrou, C. (2020, March 16). Quantifying the Impact of the New Chinese Policy. Scholarly Kitchen: Society for Scholarly Publishing. Https://scholarlykitchen.sspnet.org/2020/03/16/guest-post-quantifying-the-impact-of-the-new-chinese-policy/

Restuccia, A., Lubold, G. & Hinshaw, D. (2020, May 19). Trump Threatens to Permanently Cut Funding to World Health Organization. *Wall Street Journal.* https://www.wsj.com/articles/chinas-president-pledges-2-billion-for-coronavirus-pandemic-11589802504

Sá, C. & Sabzalieva, E. (2018). Scientific nationalism in a globalizing world. In B. Cantwell, H. Coates, & R. King (eds.). *Handbook on the Politics of Higher Education* (pp. 130-148). UK: Edward Elgar Publishing.

Scott, S. (2020, May 13). Expert survey series: Societal and geopolitical changes in a post-COVID-19 world. *Atlantic Council*. https://www.atlanticcouncil.org/blogs/geotech-cues/societal-and-geopolitical-changes-in-a-post-covid-19-world/

Sharma, Y. (2020, April 15). COVID-19 research checks could deter global collaboration. University World News. https://www.universityworldnews.com/post.php?story=20200415141352492

Schiermeier, Q. (2018). China backs bold plan to tear down journal paywalls. *Nature*, *564*, 171–172. DOI: https://doi. org/10.1038/d41586-018-07659-5

Sharma,Y. (2019, February 11). Top US research universities freeze ties with Huawei. *University World News.* Retrieved from https://www.universityworldnews.com/post.php?story=20190211124159161

Smith, M.J., Weinberger, C., Bruna, E.M., & Allesina, S. (2014). The scientific impact of nations: Journal placement and citation performance. *Plos One*. Retrieved from https://doi.org/10.1371/journal.pone.0109195

State Council, People's Republic of China (2018a, July 3). China streamlines evaluation of scientific research. http://english.www.gov.cn/policies/latest_releases/2018/07/03/content_281476207880722.htm

State Council, People's Republic of China (2018b, May 31). China issues guidelines to strengthen scientific integrity http://english.www.gov.cn/policies/latest_releases/2018/05/31/content_281476166645336.htm

State Council, People's Republic of China (2018c, January 8). Premier calls for S&T development. http://english.www.gov.cn/premier/news/2018/01/08/content_281476006240668.htm

Stensaker, B., Lee, J.J., Rhoades, G., Ghosh, S., Castiello-Gutiérrez, S., Vance, H., Çalıkoğlu, A., Kramer, V., Liu, S., Marei, M.S., O'Toole, L., Pavlyutkin I., & Peel, C. (2019) Stratified University Strategies: The Shaping of Institutional Legitimacy in a Global Perspective, The Journal of Higher Education, 90:4, 539-562,

Stevis, Gridneff M. & Jakes, L. (2020, May 4). World Leaders Join to Pledge $8 Billion for Vaccine as U.S. Goes It Alone. *New York Times.* https://www.nytimes.com/2020/05/04/world/europe/eu-coronavirus-vaccine.html

Subramayan, K. (1982). Bibliometric studies of research collaboration: A review. *Journal of Information Science 6,* 33-38.

Sun, X., Kaur, J., Milojevic, S., Flammini, A & Menczer, F. (2013). Social dynamics of science. *Scientific Reports*, 3, 1-6.

Sweileh, W. M. (2017). Global research trends of World Health Organization's top eight emerging pathogens. *Globalization and health,* 13(1), 9.

Tao, T. (2020). New Chinese Policy Could Reshape Global STM Publishing. Scholarly Kitchen: Society for Scholarly Publishing.. https://scholarlykitchen.sspnet.org/2020/02/27/new-chinese-policy-could-reshape-global-stm-publishing/

US Department of State. (2012, July) *United States – China Science and Technology Cooperation.* Retrieved from https://2009-2017.state.gov/documents/organization/197119.pdf

US White House. (2020, May 29). Proclamation on the Suspension of Entry as Nonimmigrants of Certain Students and Researchers from the People's Republic of China. https://www.whitehouse.gov/presidential-actions/proclamation-suspension-entry-nonimmigrants-certain-students-researchers-peoples-republic-china

Viglione, G. (2020, January 15). China is closing gap with United States on research spending. *Nature*. https://www.nature.com/articles/d41586-020-00084-7

Wheaton, S. (2020). Chinese vaccine would be 'global public good,' Xi says. Politico. https://www.politico.com/news/2020/05/18/chinese-vaccine-would-be-global-public-good-xi-says-265039

World Health Organization (2020). *WHO Timeline - COVID-19.* https://www.who.int/news-room/detail/27-04-2020-who-timeline---covid-19

Yan, S. (2020, May 19). China's Latest Policies: Some Backgrounds and Major Influences on Research Evaluation and Scientific Publishing. *KeAi Webinar: Changing Research Evaluation Policies in China – Insights and Impact.*

Yoon-Hendricks, A. (2018, July 25). Visa restrictions for Chinese students alarm academia. *New York Times*. Retrieved from https://www.nytimes.com/2018/07/25/us/politics/visa-restrictions-chinese-students.html

Figures

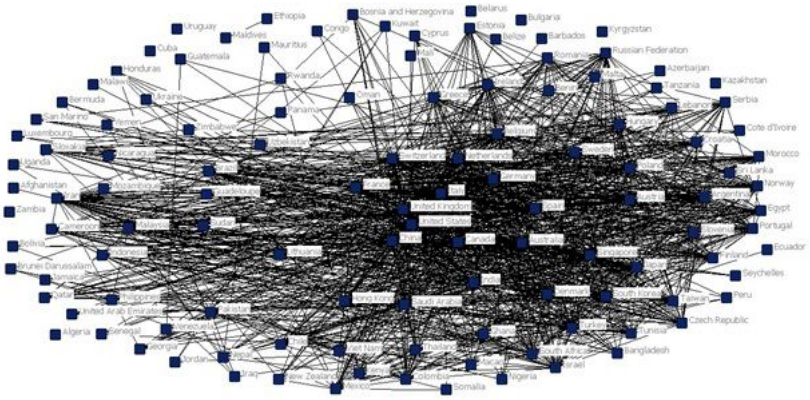

Figure 1

Network Map for 122 Countries with at least 1 COVID-19 S&E article.

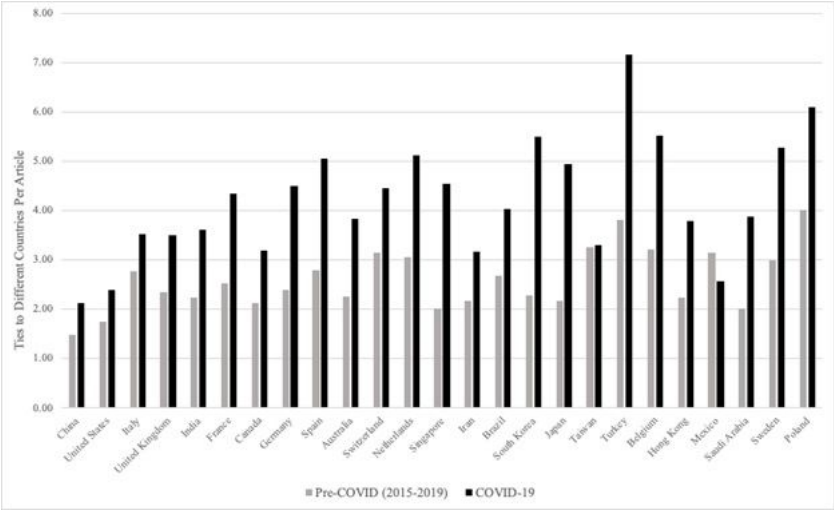

Figure 2

Average number of ties to different countries per S&E article published between 2015 and 2019 and for S&E articles on COVID-19 for the top 25 COVID-19 research producing countries

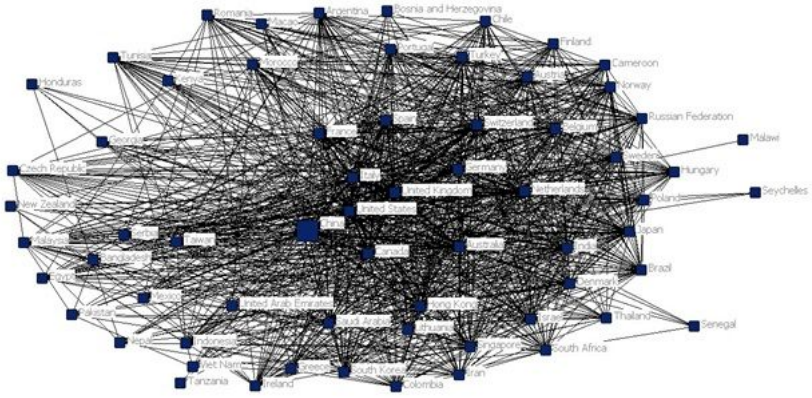

Figure 3

Network Map for China's collaborating countries on COVID-19 S&E publications.