

Scientific Collaboration on COVID-19 Amidst Geopolitical Tensions between the US and 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 examined the US' and China's international collaboration patterns on science and engineering (S&E) COVID-19 articles through the lenses of scientific nationalism and scientific globalism. 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 world's proportion of international collaborations generally increased. Findings also revealed that despite geopolitical tensions, the highest number of internationally coauthored S&E COVID-19 articles between two countries involve the US and China. Their collaboration rate on COVID-19 is higher than during the past five-years as well as on non-COVID-19 articles published during 2020.

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). Although national competition and country-first political agendas predate the pandemic, they have spilled over to scientific research. The international rivalry to hunt for a vaccine has been likened to the US-Soviet Union space race (Milne & Crow, 2020), except this time, national agendas and security are taking precedence over global health. Besides developing an effective antiviral treatment, massive scientific research efforts are underway to understand its characteristics, spread, and impact. The latest political challenges towards multilateral cooperation in addressing COVID-19 include 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, oftentimes justified as national protectionism, have slowed efforts to understand the SARS-CoV2 virus and halt its spread. Despite international cooperation efforts, resources have been diverted towards national over global research funds, such as when the European Union organized a fundraiser for coronavirus vaccine research, drawing billions of dollars of support from world leaders. The US shunned the meeting noting that the country is already investing billions of dollars in its own domestic efforts (Stevis-Gridneff & Jakes, 2020) and China opted to send its EU ambassador rather than a head of government like other countries (Milne & Crow, 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). There are also concerns about the global distribution of a future vaccine, as exemplified earlier in 2020 with the European Union, as well as numerous other countries, curbing the exports of medical supplies and equipment (Boykoff, Sebastian, & Di Donato, 2020) or luring a research company from one country for exclusive access to its potential vaccine for another country (Bennhold & Sanger, 2020). As nation-states are prioritizing their domestic interests, international relations are worsening.

At the center of the latest geopolitical conflict is the US and China, the two leading scientific knowledge producers of the world (Nature Index, 2019). Since the new coronavirus was identified, the two countries' trade war has escalated into what some are referring to as a "new cold war" (Ashford & Kroenig, 2020; Gladstone, 2020). As the two superpowers are economically decoupling, some have suggested that COVID-19 has exacerbated preexisting leanness about a possible overreliance on global trade and international supply chains (Johnson & Gramer, 2020). A looming global recession and rising populism are propelling these and other countries to look increasingly inwards in addressing societal problems. 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 the US and China. Scientific globalism and scientific nationalism provide conceptual frameworks on how the world's two superpowers are scientifically collaborating amidst geopolitical tensions. More specifically, the study observed the two countries' international scientific networks and the extent of internationally authored scientific articles on COVID-19.

US-China Research Competition and Collaboration

The US and China dominate the global scientific system. The two countries 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) while China's citation measure is increasing (NSF, 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 on the most highly cited bilateral collaborations (Authors, 2020).

The US and China are also the two largest collaborators in the world and collaborate more with each other than any two countries (Nature Index, 2019). US and China collaboration has benefited both countries' domestic science systems as well as global science more broadly. International collaboration increases each country's measure of national scientific output and also provides scientists with access to networks that enhance domestic skills and capabilities (Kaltofen & Acuto, 2018; Linkov, et al., 2016). These networks are especially essential when there are scarce knowledge, specimens, or equipment to address newly emergent concerns, such as the new coronavirus. Mutual dependence, via collaboration across borders, then becomes especially vital. Moreover, in comparison to domestic publications, internationally coauthored publications tend to have a higher number of citations (Adams, 2013; Chinchilla-Rodríguez, Vargas-Quesada, Hassan-Montero, González-Molinab, & Moya-Anegón, 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).

Among the top superpowers, the US and China have collaborated through the US-China Agreement on Cooperation in Science and Technology (the S&T Agreement) (US Department of State, 2012) to address global concerns, such as pandemic outbreak prevention and control, wildlife management and conservation practices, and renewable energy and efficiency. 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.

Geopolitical Tensions

Prior to the pandemic, the US had already proposed numerous policies on limiting scientific engagement, specifically with China. Among the attempts include denying visas to Chinese citizens (Yoon-Hendricks, 2018; US White House, 2020; Authors, 2020), banning Chinese funding sources (Sharma, 2019), and developing protocols to monitor Chinese students and scholars (Feng, 2019). These moves particularly affected the higher education sector as Chinese nationals were accused of serving as "non-traditional information collectors" at universities for China's military and strategic goals (US White House Office of Trade and Manufacturing Policy, 2018, p.14). China's Foreign Ministry denied these claims, arguing that the US has long engaged in spying on other countries and that their criticisms were unwarranted. The US Federal Bureau of Investigation (FBI) advised research universities to develop protocols to monitor Chinese students and visiting scholars (Feng, 2019), but this recommendation was met with staunch resistance from the US scientific community. Numerous prominent science, engineering, and international education organizations warned against such a sweeping approach as it could harm the overall scientific enterprise, stating that "scientific progress and US economic development have been vastly accelerated by bringing international minds together and has helped to drive innovation and discoveries" (AAAS, 2019, para. 3). Yet despite this and other domestic opposition (e.g., Committee of 100, 2019; Lu et al, 2019), Sino-American relations have worsened.

As 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 President Trump and some leaders in his administration have referred to COVID-19 as the "Chinese Virus" or "Wuhan Virus," a Chinese Foreign Ministry spokesman pushed forward a conspiracy theory that the US Army brought 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, UK, and Japan warned against malicious cyber activity, including sensitive data on COVID-19 related research (National Cyber Security Centre, 2020; Kakuchi, 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). As the pandemic continues to take hundreds of thousands of lives, the US and China are edging into a new cold war (Ashford & Kroenig, 2020; Gladstone, 2020).

Meanwhile, the sharing of COVID-19 data and study findings 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). Since then, the Trump administration ordered all hospitals to bypass the CDC and to submit all COVID-19 data to the federal government instead (US Department of Health and Human Services, 2020). Two years earlier, the US Department of the Interior screened scientific grants to "promote the priorities" of the Trump administration (Eilperin, 2018). These moves parallel findings from an earlier survey of CDC scientists that reported political interference, with the greatest barrier to science-based decisions in the organization being the White House (Union of Concerned Scientists, 2018b). There have been reports stalling or filtering COVID-19 data for political ends (Halpern, 2020) as well as cutting research grants that do not align with political allegations about the coronavirus source. For example, a major NIH-funded study on how the coronavirus moves from bats to humans was suddenly defunded without clear evidence of wrongdoing. Scientific experts expressed worry about such political obstruction because the study countered conservative US politicians and media unsubstantiated claims that SARS-CoV-2 escaped from a laboratory in Wuhan, China (Wadman & Cohen, 2020). Such so-called "highly political" steps taken by both governments, have 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; Union of Concerned Scientists, 2019).

Conceptual Frameworks

Scientific nationalism as zero-sum

Much of the political rhetoric and domestic-oriented policies discussed above demonstrate the geopolitics of science in which scientific inquiry may be secondary to national interests.

Among the features of science in relation to international relations is that it increases linkages and dependencies (de la Mothe & DuFour, 1991), so that international collaboration is a relational tool that builds national security and prestige. In addition to informing militaristic forms of hard power (Nye, 1990), knowledge, science, and technology serve as currency for soft power as countries cooperate or compete (de la Mothe & DuFour, 1991; 1995). Governments have long played an active role in funding scientific research towards nation-building and global competitiveness. For smaller countries on the periphery of the scientific enterprise, working with scientists abroad is especially vital in pooling and maximizing resources. Thus, international collaboration can be framed as representations of scientific nationalism, which essentially views scientific research as a means to primarily advance the nation-state, but not at the expense of it.

Scientific findings do not always align with political agendas. Based on scientific nationalism, governments may then intervene for the welfare of the state. According to a survey of over 63,000 U.S. federal scientists in 16 government agencies, respondents reported the White House and its political appointees as among the leading barriers to protecting public health (Union of Concerned Scientists, 2018a). Federal scientists reported interference from government officials with half indicating that political interests hindered the ability of their agencies to make science-based decisions. The challenges from the Trump administration have included reports of scientific studies being halted, edited or suppressed, the sidelining of scientific advice, and political oversight over grant reviews (Carter, Berman, Desikan, Johnson, & Goldman, 2019).

From a nation-state's interests, COVID-19 represents both a political and security issue related to public health. Based on an international study of state capacities in response to pathogenic agents (e.g., HIV, Ebola virus, Hepatitis A-C), Price-Smith (2002) concludes that infectious disease poses direct threats to national security and state power, as they have the potential to destabilize the economy and political structures. Thus, securitization occurs when an issue is given sufficient saliency as an emergency threat, enabling authorities to handle the issue by whatever means they deem most appropriate (Balzacq, Léonard, & Ruzicka, 2016). Health crises have been and continue to be securitized. Especially given the enormity of the US and China's scientific systems, and thus less dependence on resources from abroad, international collaboration may appear unnecessary. Universities that host internationals have been described by the US federal government as 'vulnerable' to espionage and intellectual theft (US Department of Justice, 2018, p. 3). The current pandemic has been framed as a direct threat to "national security" (US White House, 2020b), which aligns with the "China Threat" narrative, such as labeling SARS-CoV2 as the "Chinese virus." Thus, the securitization of COVID-19 becomes a national over humanitarian pursuit addressing what is presented as a threat coming from outside domestic borders. China has also engaged in securitization, as evidenced by its handling of SARS and avian influenza pandemics, in which resources were not immediately allocated until the leadership highlighted these as urgent problems (Wishnick, 2010). Another example is the Chinese Academy of Sciences' notice that the government must approve any COVID-19-related research publications (Gan, Hu, & Watson, 2020).

Among the criticisms is that when public health is securitized, it is also politicized, leading to centralized decision making that could suspend human freedoms or rights in the name of national protection (Daoudi, 2020). For citizens, this means closing national borders to so-called 'foreigners' but allowing the re-entry of repatriates. For scientists in particular, this means limiting international engagement with scientists from countries that are believed to pose a threat to national security. States may interfere (i.e., limiting access to data, political screening of grants and communication of scientific information). Based on this zero-sum view, one would expect that COVID-19 research may increase quickly, 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).

Scientific globalism as synergy

At the same time, science is inherently global and becoming increasingly transnational as scientists collaborate across borders. This can especially be evidenced by nongovernmental actors, international organizations, and transnational corporations' significant roles in setting norms, prioritizing governmental agendas and funding research. The emergence of global agendas, such as 'global health' transcends the nation-state. Based on Davies (2010) comparison of statist (national) and globalist approaches to public health, among the differentiating characteristics is that the former centers the state to best manage health threats in the interests of the state system (i.e., national security) whereas the latter centers on individuals (i.e., good health). The author and others have advocated for a globalist approach that is more concerned with health equity, warning that in some situations the state may pose the greatest threat to

individuals' health and human security (Davies, 2010; Ogata & Sen, 2003). According to scientific globalism, political interference may result in the reduction of valuable knowledge that would support public health

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, security, 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; Authors, 2020). 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, Authors (2020) 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.

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 (Eduan & Yuanqun, 2019). 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. What this means in the midst of a global health crisis and heightening geopolitical tensions was the purpose of the study.

Methods

This study sought to examine the extent of international science and engineering (S&E) research collaboration on COVID-19, with particular attention on the US and China. This focused analysis on the US and 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 112 countries that had published research on COVID-19 as of May 9, 2020 (Authors, 2020). Findings from our earlier study demonstrated an increase of international collaborations in addressing a COVID-19. Among main findings are that countries are working together more now on COVID-19 than compared to the past five years and compared to non-COVID-19 research this year. We further found that in predicting the likelihood of COVID-19 collaboration, countries that have been more impacted by the crisis and those with relatively lower GDPs tended to participate more in international collaboration than their counterparts. For this study, we focused on US and China and asked: 1) What are the US' and China's scientific collaboration networks on COVID-19, as measured by co-publications, amidst current geopolitical tensions? 2) How do the two countries' collaborations on COVID-19 compare to pre-pandemic and on non-COVID-19 publications?

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.

Three datasets were created and compared: a) S&E article publications from January 1, 2015 to December 31, 2019, b) COVID-19 S&E article publications from January 1, 2020 to May 25, 2020, and c) all other S&E article publications from January 1, 2020 to May 25, 2020. The 2015-2019 dataset was created in order to calculate the average percentage of international publications across a five-year time period, as a stable measure of collaboration prior to the pandemic. The COVID-19 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, while the non-COVID-19 articles data set for the same time frame was based on the exclusion of these terms. 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.

For the three 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, a frequent counting method applied in the analysis of global network structures (Finardi, 2015; Leydesdorff & Wagner, 2008; Wagner & Leydesdorff, 2005), so that an article was counted toward each co-authoring country's total number of publications.

Three measures were calculated to compare the COVID-19 2020, 2015-2019, and non-COVID 2020 data sets. First, the number and percentage of international collaborations were calculated and statistically compared to understand global patterns of collaboration on COVID-19 research. 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. Chi-square test of independence were performed to compare the percentage of international collaborations for the COVID-19 2020, 2015-2019, and non-COVID 2020. The same test was also applied to US and China international collaboration patterns to determine whether the countries were collaborating internationally more or less on COVID-19. Second, the number and percentage of the US' and China's international collaborations with the top 25 S&E COVID-19 research producing countries were calculated and compared. This analysis provides insight into US and China international collaboration patterns with particular countries on COVID-19 research. Third, to provide insight into the identified trends in collaboration, the average number of ties to different countries per article was calculated for the US and China. This measure was calculated by summing the total number of ties to other countries that the US and China had for the COVID-19 2020, 2015-2019, and non-COVID 2020 data, 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 more other countries 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, three network maps were constructed in NetDraw (Borgatti, 2002): a network map including all countries that published at least one article related to COVID-19, an ego-network map of the US' COVID-19 collaboration network, 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

Following a contextual overview of global collaboration, the results present the US' and China's scientific collaboration networks on COVID-19, as measured by co-publications, and how the two countries' collaboration patterns on COVID-19 compare to pre-pandemic and on non-COVID-19 publications.

Global Collaboration

122 countries published at least one 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.

[Figure 1 here]

Findings further indicate international collaboration intensified during a global crisis, even despite international tensions. According to Table 1, the world's proportion of international collaboration on COVID-19 (32%) was higher than recent years, prior to the pandemic (26%). The difference between the two time periods was statistically significant [$\chi^2(1)=100.015$, $p < .001$]. COVID-19 collaboration was also significantly higher (4%) than non-COVID-19 research during the same time period [$\chi^2(1)=38.947$, $p < .001$].

[Table 1 here]

As of the end of May 2020, China led in COVID-19 publications (1350), followed by the US (936), although the US has maintained a higher international collaboration rate than China. As shown in Table 2, US' proportion of international collaborations on these publications (39%) was significantly less than those prior to the pandemic (44%) and non-COVID-19 publications (46%). Similarly, China's proportion of internationally authored COVID-19 publications (19%) was also less than the past (21%) and compared to non-COVID-19 publications (24%).

[Table 2 here]

While the percentage of collaboration for both the US and China was less than the two comparison data points, the average number of country collaborators per article increased. US's average increased from an average of 1.7 country ties per article from 2015-2019 to 2.4 on COVID-19 research. China also slightly increased from an average of 1.5 to 2.1. These average for COVID-19 publications was also higher than non-COVID-19 publications for both countries (See Figure 2). Thus, both countries produced a higher proportion of domestic research but also engaged more multilaterally on COVID-19 scientific articles.

[Figure 2 here]

Collaboration with US

The US' collaboration patterns on COVID-19 research (Figure 3) showed that the US collaborated with a total of 77 countries on COVID-19 research from January 1, 2020 to May 25, 2020. As is mentioned above, on its international collaborations, it had ties to 867 countries. The US' top collaborators were China, Canada, the UK, Italy, and Australia. Scientists from the US collaborated with scientists from these five countries on more than 40 publications each. Despite geopolitical strains, the US collaborated with China at a rate 1.7 times higher than with its second and third highest collaborators, Canada and the UK.

[Figure 3 here]

Table 3 shows the proportion of the US' international collaborations with the top 25 COVID-19 research producing countries across the three data sets. The US has generally maintained or increased its proportion of internationally collaborated articles with these top COVID-19 research producing countries. In almost all cases, the percent change on COVID-19 collaborations was about the same when comparing COVID-19 data to 2015-2019 and non-COVID-19 data, which suggests the enduring strength of preexisting international ties. Among the most notable increases in COVID-19 collaboration were with Italy, Canada, China, and the UK. As previously discussed, the US' lead collaborator on COVID-19 publications was China. Collaborations with China accounted for 33.61% of the US' international collaborations on COVID-19. This proportion was significantly higher than the 5 years prior (8% increase), and it was also higher than non-COVID articles during the 2020 timeframe (4% increase), although the latter was not significant. Furthermore, in comparing non-COVID-19 co-publications with co-publications prior to the pandemic, the proportion of the US' international collaborations with China increased as well (29% versus 26%).

[Table 3 here]

Collaboration with China

Next, we observed China's collaboration patterns on COVID-19. According to Figure 4, China had a total of 545 ties with 64 countries on COVID-19 related research. China collaborated the most with the United States, the UK, Canada, Hong Kong, and Australia having engaged in least 30 collaborations with each of these countries. However, like with US' collaborations, 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.

[Figure 4 here]

Further, regarding the proportion of China's international collaborations with the top 25 COVID-19 research producing countries across the three data sets, China either maintained or increased its proportion of international collaborations with each country (Table 4). Similar to the US bilateral collaborations, the percent change on COVID-19 collaborations was approximately the same when comparing COVID-19 data to 2015-2019 and non-COVID-19 data in nearly all cases. Moreover, despite current political strains, the US continued to be China's lead international collaborator. Almost half of China's COVID-19 international articles included US authors, which reflects a 6% increase compared to pre-COVID-19. Yet, findings further suggested that China's proportion of publications with the US on non-COVID-19 articles is declining. Whereas 42% of the country's international articles were co-authored with the US over the past 5 years, in 2020, that percentage declined to 37%. This drop suggests some slippage in China's cooperation with the US, except on COVID-19 studies. The UK was the second lead collaborator, also showing an increase (7%). Like with the US, China's most notable increase per country was Italy (9%), likely reflecting the country's high caseload early in the pandemic.

[Table 4 here]

Conclusion

COVID-19 has become a global health crisis as well as spurred international divisions. This study sought to understand the extent of international collaboration on COVID-19 research through the lenses of scientific nationalism and scientific globalism. As scientific nationalism would suggest, when countries focus on domestically oriented interests in the midst of an urgent worldwide crisis, there may be detrimental effects on the world's ability to effectively respond. Meanwhile, scientific globalism is still possible as scientists may continue to collaborate, share knowledge, and disseminate findings for the advancement of global health. This research study paid special attention to US and China because of their leading role on publications and international collaborations, including on COVID-19 research.

Consistent with previous research (Authors, 2020), at a global level, there is a higher proportion of internationally co-authored papers on COVID-19 than internationally co-authored papers in the past or on non-COVID during the same time period. Related specifically to the US and China, they lead in COVID-19 publications and collaborate more with each other than any two countries on this research. Despite ongoing political conflicts between the two country leaders, the US continues to be China's lead international collaborator and vice versa. For both the US and China, among their internationally co-authored articles on COVID-19, their rate of collaboration with each other is higher compared to pre-COVID-19 and non-COVID-19 articles. In other words, the US and China are especially cooperating on COVID-19 research. This point is underscored when observing that China's proportion of international collaborations with the US on non-COVID-19 research is less than five years prior, suggesting an otherwise downward trend for China's scholarly engagement with the US. Furthermore, the two countries engaged with more country authors on COVID-19 research articles than prior to the pandemic and non-COVID-19 papers during the same 2020 timeframe, providing further evidence for enhanced scientific globalism during the pandemic.

We also found that the US' and China's overall proportions of domestic papers on COVID-19 are higher than prior to the pandemic and more than non-COVID-19 papers during the same 2020 timeframe. While this finding may suggest evidence of scientific nationalism, or a domestic orientation of US and Chinese scientists in response to the pandemic, this decline in proportion of international collaborations could be due to US and Chinese scientists having access to resources needed to engage in COVID-19 research. Based on our previous study (Authors, 2020), scientists from countries with higher GDPs were less likely to collaborate on COVID-19 articles than scientists from economically less developed countries. Therefore, the availability of resources may reduce US and Chinese scientists' choices to collaborate internationally during a time of crisis when long distance collaboration may impede the research process.

Through the lenses of scientific nationalism and scientific globalism, the findings further confirm that countries can pursue both scientific nationalism and scientific globalism at the same time, as global research networks organize beyond national interests. While scientific nationalism would assume that the current political rhetoric and protectionist policies would correspond with a decline in international collaboration, the findings show that that scientists are generally not curbed by tensions and policies that primarily promote the interest of the nation-state as international collaboration continues and even grows. Essentially both are possible because political leaders, national policy makers, and scientists may be operating with different logics. While scientific nationalism is the main logic being espoused at the political level during this time, particularly by the US, scientific globalism appears to be the logic being utilized by the scientists themselves. Politicians seek to promote the nation-state and engage in science primarily through a narrow lens of national development and national security, while scientists may find their allegiance to a scientific community that is less bound by political, ethnic and cultural borders. To them, they work to engage in scientific inquiry with the goal of advancing knowledge and improving the human condition, in this case, helping humans overcome COVID-19. Scientists may be especially inclined to collaborate on this issue due to the urgent global need to understand the virus, to develop effective treatments, including a vaccine, and to address future prevention.

Thus, international research collaborations are not determined by national interests or 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 and their institutions 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 international cooperation patterns are sustained, even despite the geopolitical rivalry. Previous research found that even when scientific competition might exist, researchers are not less inclined to collaborate but constrain their set of possible collaborators instead (Birnholtz, 2007). Rather than eliminating an entire country, scientists are likely working with particular individuals with whom there is a trusted relationship. Thus, it is important to recognize that international ties can both self-regulated and politically imposed (Horváth, Weber, & Wicki, 2000).

While the findings offer important contributions as a national-level analysis and suggest the power of individual agency, scientists are also influenced by organizational policies as well as individual factors that may impact their choice to collaborate internationally. Due to this, future research should investigate not only how organizations influence individual collaboration choices during a global crisis, but also how national policies and geopolitical tensions interact at the organizational and individual levels to influence collaboration patterns. Moreover, this study primarily incorporated a US perspective on US-China research collaboration, which ultimately limits our understanding of how China's policies may influence their collaboration patterns with the US. Future research should thus further explore China's domestic and international policy agenda and practices.

This research was conducted during the early stages of the pandemic, which provides only a snapshot of how scientists collaborate during a global crisis. These collaboration patterns may change as the pandemic continues and as countries are affected differently. Future research may seek to investigate collaboration patterns as they continue to evolve and as tensions between countries continue to escalate. For the post-COVID future, this study raises new questions about scientific collaboration in addressing global challenges in the midst of rising nationalism. 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. Meanwhile, geopolitical tensions between the US and China continue to intensify and will likely endure beyond the current pandemic. With the US and China's declines in their respective proportions of international research papers on COVID-19, the two countries may continue to look more inwardly, but the fate of the research relationship between the two countries' in the long run is uncertain. What is even less clear is how to engage amidst national rivalries that coopt science for political purposes or worse, deny science because it counters political agendas. Scientific globalism would call for empirical knowledge to inform international and domestic strategies, not the other way around. Decoupling science from politics, supporting scientific inquiry, and encouraging cross-border investigations are obvious steps, but also challenging when science becomes a matter of national security (i.e., scientific nationalism). Thus, an added area for further directive would be science diplomacy, by which science can promote international relations (Flink & Schreiterer, 2010). Already, our findings suggest this is happening, at least among scientists. Regardless, the shape of global science is changing but scientific globalism is certainly not going away.

Declarations

The authors declare no competing interests.

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Tables

Table 1. Frequencies of single country publications and international publications for COVID-19 articles, articles published between 2015 and 2019, and non-COVID-19 2020 articles.

Time Period	Total Publications	Total Single Country Publications	% Single Country Publications	Total International Collaborations	% International Collaborations
COVID-19	4,878	3,325	68.16%	1,553	31.84%
2015-2019	8,184,254	6,090,180	74.41%	2,094,074	25.59%
Non-COVID-19 2020	600,505	433,473	72.23%	167,032	27.77%

Table 2. Percentages of single country publications and international publications for COVID-19 articles, articles published between 2015 and 2019, and non-COVID-19 2020 articles for the US and China.

Country	% International Collaborations on COVID-19	% International Collaborations on 2015-2019	% Difference (COVID-19 - 2015-2019)	% International Collaborations on non-COVID 2020	% Difference (COVID-19 - non-COVID 2020)
United States	38.78%	44.20%	-5.42%***	46.02%	-7.24%***
China	18.96%	21.20%	-2.24%*	23.50%	-4.54%***

* = $p \leq .05$; ** = $p \leq .01$; *** = $p \leq .001$

Table 3. Percent of US' international collaborations for COVID-19 articles, articles published between 2015 and 2019, and non-COVID-19 2020 articles with the top 25 COVID-19 research producing countries

Country	Total Collaborations with US on COVID-19	% of US' COVID-19 International Collaborations	% of US' 2015-2019 International Collaborations	% Difference (COVID-19 - 2015-2019)	% of US' non-COVID 2020 International Collaborations	% Difference (COVID-19 - non-COVID 2020)
China	122	33.61%	25.80%	7.81%*	29.22%	4.38%
Canada	71	19.56%	10.10%	9.46%***	10.17%	9.39%***
United Kingdom	70	19.28%	13.19%	6.09%**	12.68%	6.60%***
Italy	65	17.91%	6.55%	11.35%***	6.58%	11.33%***
Australia	40	11.02%	6.21%	4.81%***	6.39%	4.62%***
Germany	35	9.64%	11.51%	-1.86%	10.77%	-1.13%
Spain	31	8.54%	5.11%	3.43%**	5.13%	3.41%**
France	27	7.44%	7.67%	-0.24%	7.27%	0.17%
Netherlands	25	6.89%	4.69%	2.19%	4.80%	2.09%
Japan	20	5.51%	5.71%	-0.21%	5.38%	0.13%
Switzerland	20	5.51%	4.57%	0.94%	4.42%	1.09%
Mexico	19	5.23%	1.86%	3.37%***	2.40%	2.83%***
India	18	4.96%	3.64%	1.32%	3.50%	1.46%
Singapore	17	4.68%	1.47%	3.22%***	1.50%	3.19%***
Hong Kong	14	3.86%	1.33%	2.53%***	1.34%	2.52%***
Saudi Arabia	14	3.86%	1.52%	2.34%***	1.47%	2.39%***
South Korea	14	3.86%	5.02%	-1.17%	4.67%	-0.82%
Belgium	13	3.58%	2.44%	1.14%	2.56%	1.03%
Brazil	11	3.03%	4.14%	-1.11%	4.22%	-1.19%
Poland	11	3.03%	1.86%	1.17%	1.87%	1.16%
Sweden	11	3.03%	3.32%	-0.29%	3.13%	-0.10%
Iran	8	2.20%	1.50%	0.71%	1.85%	0.35%
Taiwan	6	1.65%	2.12%	-0.47%	2.09%	-0.43%
Turkey	5	1.38%	1.60%	-0.22%	1.49%	-0.11%

* = $p \leq .05$; ** = $p \leq .01$; *** = $p \leq .001$

Table 4. Percent of China's international collaborations for COVID-19 articles, articles published between 2015 and 2019, and non-COVID-19 2020 articles with the top 25 COVID-19 research producing countries

Country	Total Collaborations with China on COVID-19	% of China's COVID-19 International Collaborations	% of China's 2015-2019 International Collaborations	% Difference (COVID-19 - 2015-2019)	% of China's non-COVID 2020 International Collaborations	% Difference (COVID-19 - non-COVID 2020)
United States	122	47.66%	42.08%	5.58%	37.46%	10.20%*
United Kingdom	45	17.58%	10.19%	7.39%***	11.11%	6.47%**
Canada	33	12.89%	6.96%	5.93%***	7.25%	5.64%**
Hong Kong	33	12.89%	7.33%	5.56%**	6.72%	6.17%**
Australia	32	12.50%	9.32%	3.18%	10.08%	2.42%
Italy	29	11.33%	2.50%	8.83%***	2.47%	8.86%***
Germany	18	7.03%	6.68%	0.35%	6.63%	0.40%
Japan	16	6.25%	6.46%	-0.21%	6.63%	-0.38%
France	12	4.69%	4.18%	0.51%	3.98%	0.71%
India	12	4.69%	1.85%	2.84%***	2.20%	2.49%**
Singapore	12	4.69%	3.84%	0.85%	3.87%	0.82%
Spain	12	4.69%	2.05%	2.64%**	2.00%	2.69%**
Switzerland	12	4.69%	1.72%	2.97%***	1.58%	3.11%***
Taiwan	11	4.30%	3.04%	1.25%	2.82%	1.48%
Netherlands	10	3.91%	2.29%	1.62%	2.22%	1.69%
South Korea	10	3.91%	3.56%	0.34%	3.64%	0.27%
Saudi Arabia	9	3.52%	1.80%	1.72%	1.87%	1.65%
Belgium	7	2.73%	1.29%	1.45%*	1.28%	1.45%*
Sweden	6	2.34%	2.20%	0.15%	2.12%	0.22%
Mexico	3	1.17%	0.56%	0.61%	0.54%	0.63%
Poland	3	1.17%	1.09%	0.08%	1.08%	0.09%
Turkey	3	1.17%	0.80%	0.37%	0.83%	0.34%
Brazil	2	0.78%	1.15%	-0.37%	1.01%	-0.23%
Iran	2	0.78%	0.80%	-0.01%	1.27%	-0.49%

* = p ≤ .05; ** = p ≤ .01; *** = p ≤ .001

Figures

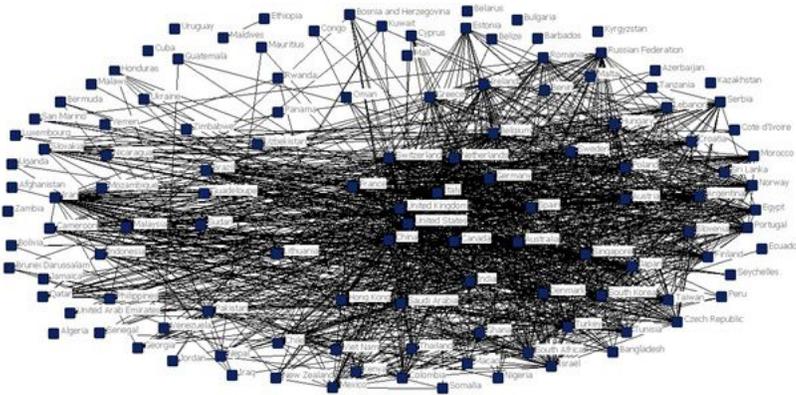


Figure 1

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

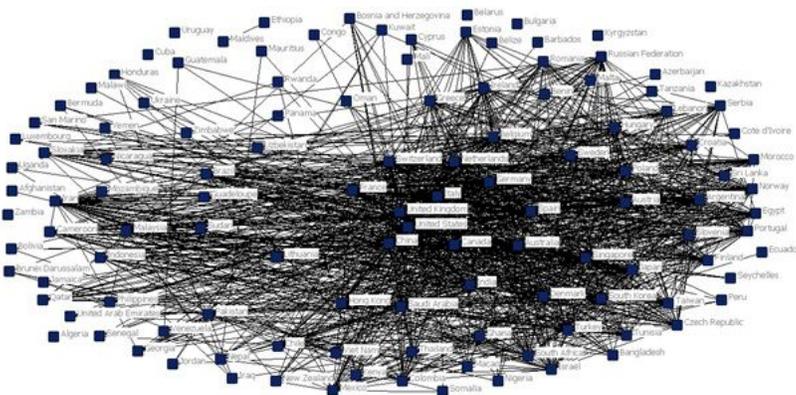


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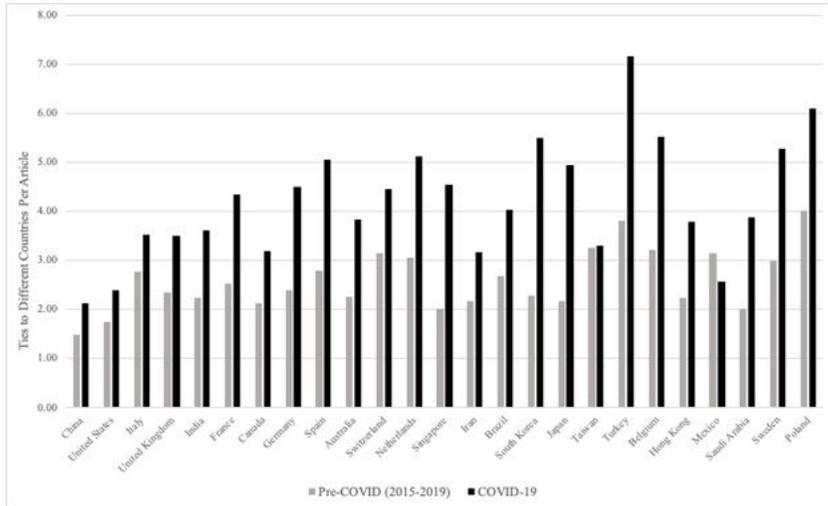


Figure 2

Average number of ties to different countries per COVID-19 articles, articles published between 2015 and 2019, and non-COVID-19 2020 articles for China and the US

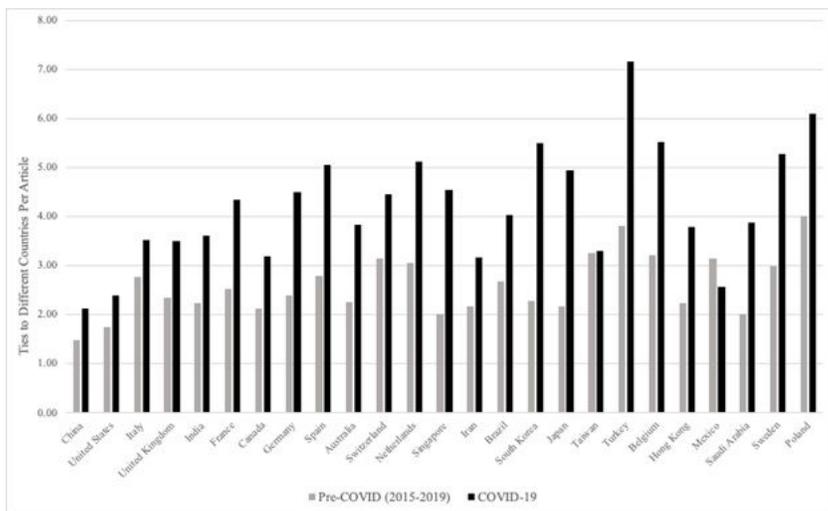


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Average number of ties to different countries per COVID-19 articles, articles published between 2015 and 2019, and non-COVID-19 2020 articles for China and the US

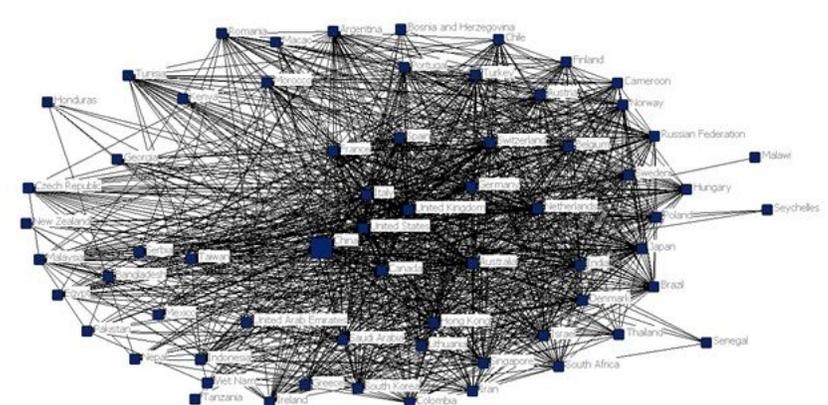


Figure 3

Network Map for US' collaborating countries on COVID-19 publications.

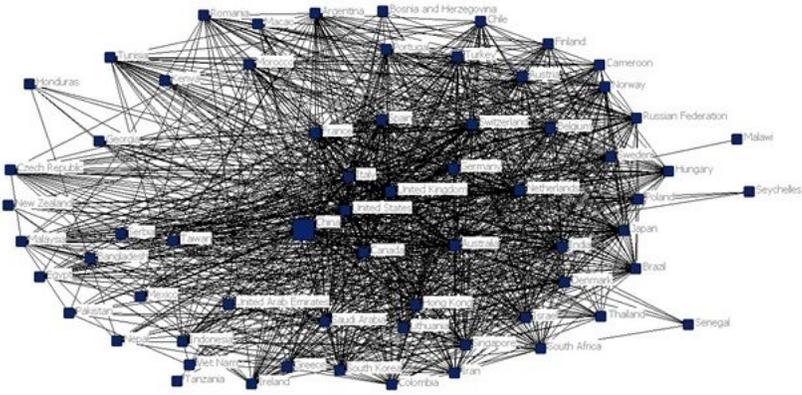


Figure 3

Network Map for US' collaborating countries on COVID-19 publications.

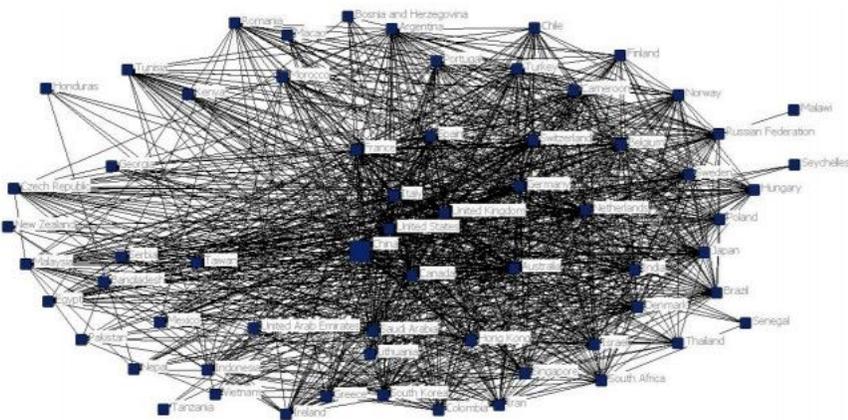


Figure 4

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

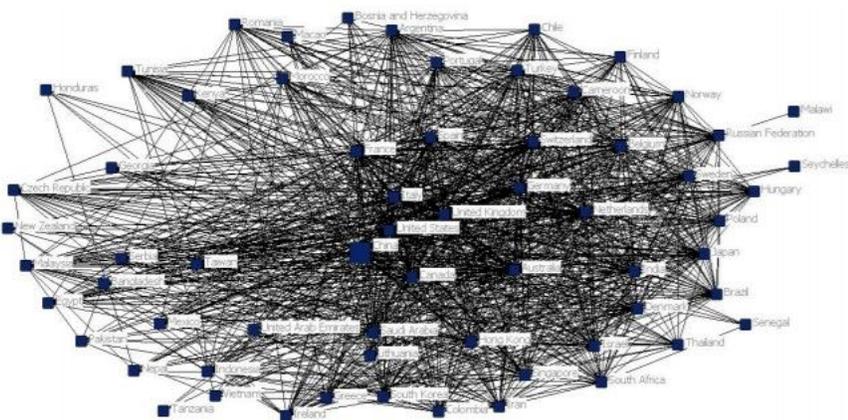


Figure 4

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