SHIFTING GEOGRAPHIES OF KNOWLEDGE PRODUCTION: THE CORONAVIRUS EFFECT

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ABSTRACT
This research note analyses the evolving geographies of coronavirus disease research before and during the first three months of the 2020 epidemic outbreak. An examination of global networks of scientific co-production highlights the increasing centrality and knowledge intermediation profile of Chinese organisations. It is argued that it is important to understand these global geographies and networks, as they may signal varying (and cumulative) abilities to generate, intermediate, and access relevant knowledge in the face of epidemic outbreaks.

Key words: Coronavirus; COVID-19; Ebola; geography of innovation; global innovation systems; social network analysis

EPIDEMICS AND URGENT KNOWLEDGE PRODUCTION

Epidemic outbreaks have caused major changes throughout human history, and they have increased in frequency over the last few years (Friedman 2020). The worldwide impact of COVID-19 has sounded alarms in a manner that has not been seen in recent history. In fact, since the World Health Organization created the Public Health Emergency of International Concern (PHEIC) mechanism in 2005, it has already been activated six times. Among the other social, economic, and political transformations they bring (Alfani & Murphy 2017), large epidemic outbreaks are accompanied by fast-paced scientific and technological activity since they represent imminent threats to human life (Colf et al. 2016).

The Ebola outbreak in West Africa in 2014 is illustrative of this effect. Research shows that the epidemic amplified Ebola-related knowledge production on a global scale (e.g. Quarcoo et al. 2015), creating new interdependencies between scientists, medical practitioners, and inventors. Related scientific articles and clinical trials soared, but what was more telling was the geographical reconfiguration of knowledge creation activity, placing the most affected African countries as relevant hubs in global co-authorship and collaboration networks – notwithstanding the enduring centrality of traditional science hubs in North America and Europe, before and during the outbreak (e.g. Hegel et al. 2017). However, this shifting geography was not seen in terms of patent co-inventorship, such as in drug development and other clinical innovations. In this case, those who were able to ‘anchor’ knowledge networks (Crevoisier & Jeannerat 2009; Vale & Carvalho 2013; Binz & Truffer 2017) and become important co-inventors came from countries and regions endowed with scientific and technological infrastructure like universities and research labs (e.g. World Intellectual Property Organization 2019).
It was ultimately through these geographically nuanced networks that the development of new drugs and technologies to fight the epidemic accelerated (World Health Organization 2019).

Of course, it is still early to identify the effects of the COVID-19 outbreak in this respect in detail. However, the aforementioned findings may suggest future directions in terms of the changing structure and geography of the related knowledge production systems that will emerge from – and because of – the crisis. To explore this issue, this note examines the evolving geography of coronavirus knowledge production networks, assessed through co-authorship in scientific publications indexed at the Web of Science. This measure is admittedly imperfect, as it primarily captures the research-driven and analytical modes of knowledge production (Davids & Frenken 2018). It serves as a first image of the global geographies of scientific and technological efforts to understand, mitigate, and deal with coronavirus disease at a time in which complementary data such as clinical trials and patent claims are still emerging. The note concludes by hypothesising the foreseeable contours of the changing geography of coronavirus research, in which China’s role as a knowledge producer and network connector will likely become heightened. Moreover, it sketches several challenges for research in social and economic geography in this shifting context.

THE GEOGRAPHY OF CORONAVIRUS RESEARCH

Methods – In order to assess the structure of coronavirus disease-related scientific co-authorship through the Web of Science database, search criteria included the words CORONAVIRUS, COVID, and SARS (i.e., Severe Acute Respiratory Syndrome) across publications titles, abstracts, and keywords. The term SARS was included due to the similarities between COVID-19 and SARS-type coronaviruses (between 50% and 87% genetic similarity, according to Lu et al. 2020). Data were collected and analysed for two periods: 2010–2019 (before the current outbreak) and during the first three months of 2020 (after the outbreak). Since the virus responsible for COVID-19 is new, it is not possible to directly compare recent scientific publications on the subject with those before the epidemic. However because of the structural proximity of COVID-19 and SARS coronaviruses, and considering that drug repurposing is an effective and often-followed (lower-cost) strategy (Zhou et al. 2020), it is reasonable to assume that new knowledge development in these fields will build upon and will be highly related to previous research efforts.

The analyses included a measure of the (co-)authorship share of each country (WoS weight) as well as the individual weight of co-authorship dyadic connections across countries (connection weight), as depicted in Figure 1 and Figure 2. Moreover, social network analysis was used to assess each country’s centrality in the global network of coronavirus disease research. For the latter, betweenness centrality (Hanneman & Riddle 2005) was also calculated, that is, a measure assessing the number of times a certain entity (in this case, a country) represents the shortest path between two others for scientific co-production. This provided a proxy for the role of different countries as knowledge nodes and intermediation hubs in the geography of coronavirus disease research, as represented in Figure 1 and Figure 2.

Results – As witnessed for previous epidemic outbreaks (e.g. Quarcoo et al. 2015; Hegel et al. 2017), the current COVID-19 outbreak boosted related scientific efforts in a very short period. The absolute number of publications increased by 300 per cent during the first three months of 2020, making up for an average of 182 monthly articles (compared with an average of 54 monthly articles during 2010–2019).

In the years before the current outbreak, research organisations in the United States of America had the highest number of co-authorships (33,4%), followed by organisations in China (22.6%), the United Kingdom (6.7%), Germany (6.5%), Saudi Arabia (6.5%), South Korea (6.3%), and the Netherlands (5%), with other countries producing less than 5% of the global research output (Figure 1). The
Figure 1. Co-authorship networks in coronavirus research (January 2010–December 2019). [Colour figure can be viewed at wileyonlinelibrary.com]

Source: Author’s elaboration based on the Web of Science.

Figure 2. Co-authorship networks in coronavirus research (January–March 2020). [Colour figure can be viewed at wileyonlinelibrary.com]

Source: Author’s elaboration based on the Web of Science.
presence of Saudi Arabia in this rank provides an illustration of the impact of epidemic outbreaks on the geography of knowledge production; Saudi Arabia was the epicentre of the MERS-CoV epidemic in 2012. A similar pattern occurred with the SARS-CoV epidemic in China and South Korea in 2002: research in those fields has endured in these countries ever since.

However, significant changes have occurred as a result of the current outbreak (Figure 2). Between January and March 2020, Chinese institutions began leading the ranks, taking part in 36.3% of the global research output, followed at some distance by the United States (17.8%), the United Kingdom (5.9%), and Canada (4%). Beyond its role as an increasingly important knowledge hub, this rapid change is quite naturally linked to the fact that China was the epicentre of the COVID-19 epidemic for many weeks. The same effect can be seen in the case of Italy; Italian organisations became the seventh-most prevalent globally in coronavirus disease research (3.8% of global research output compared to 2.9% before the crisis). Moreover, while traditional coronavirus disease research countries maintained important positions (e.g. Saudi Arabia, Germany, the United Kingdom, and South Korea), others reinforced their centrality in global research networks (e.g. Canada).

A telling picture emerges when, beyond size, countries are assessed in relation to their ability to intermediate knowledge flows through the measure of betweenness centrality (Figure 1 and Figure 2). After the current outbreak, China and the United Kingdom outpaced the USA, and European counties reinforced their strategic position. Moreover, new countries gained centrality, notably Australia, in Africa (South Africa and Nigeria) and Latin America (Brazil and Colombia). Another important element pertains to the number of publications co-authored between pairs of countries, assessing the strength of the research links between them. Before the outbreak, the link between the United States and China was the strongest (5.7% of the total number of publications was co-authored by researchers in both countries), followed by co-authorship links between the United Kingdom (2.7%) and USA–Saudi Arabia (3.2%). After the outbreak, the USA–China link remained the strongest (5.6% of the total number of co-authorships), but China significantly intensified its research links within Asia (e.g. with India, Taiwan, and Thailand) and with the United Kingdom, Australia, and Canada, becoming a pivotal connector in coronavirus disease knowledge production networks.

EXPECTATIONS AND IMPLICATIONS

As observed, and in line with many other knowledge production systems (Binz & Truffer 2017), the geography of coronavirus disease knowledge production, at least when assessed through scientific research, exhibits a markedly global and interconnected pattern. This geography has a deep-rooted structure that has been carved through previous collaborations and long-term relationships. However, it is also prone to being occasionally reshaped by external shocks and critical events (such as epidemic crises) that accelerate the production and diffusion of urgently needed research. On these occasions, as has been observed in other contexts (Quarcoo et al. 2015; Hegel et al. 2017), locations in which the most severe epidemic episodes take place tend to enhance their role in such networks. This pattern is easily understandable. On the one hand, countries at the forefront of an epidemic outbreak have incentives – as well as social and political support – to mobilise their science systems, activate new funding vehicles, and shift research priorities. On the other hand, countries that are later in the diffusion curve may wait for the epidemic to become less urgent.4

Although the Chinese position was already very relevant before the coronavirus disease emerged – partly as a by-product of the not-so-distant SARS crises – its research institutions doubled the number of related scientific productions since the recent outbreak. Perhaps more significantly, this has propelled China to become a major global hub and knowledge connector for different countries and networks in coronavirus disease research. At the time of writing, the epicentre of the epidemic (now pandemic) has moved to Europe and the USA, and it is thus still early to perceive the full picture of the results of the global outbreak – both in terms of science production and more applied technological development. In
those geographies, although priority shifts in science and technology investments are to be expected, the vast amount of funds and policy attention channelled to fighting economic depression and keeping social security and health systems afloat render the final effect in global knowledge production systems uncertain.

The unprecedented socio-economic conditions, together with the decrease of the epidemic curve in China, suggests that beyond serving as a temporary ‘stage’ of the epidemic, China may be on track to ‘anchor’ and forge new knowledge leadership on coronavirus disease, namely as it has the combined presence of technological infrastructure, a trajectory in related research, and practical experience in clinical trials. In fact, on 4 April 2020, the International Clinical Trials Registry Platform (ICTRP) identified 780 clinical trials related to COVID-19, out of which 596 (76%) involved Chinese organisations (WHO 2020), though these numbers are expected to rise in Europe and the USA (COVID-19 Clinical Research Coalition 2020).

In other words, it can be hypothesised that there will be ‘first-mover advantages’ and lasting effects in knowledge production among the places that are firstly hit by such an epidemic, under the condition that they are endowed with relevant science and technology resources and competences.

To be sure, testing this hypothesis would require following-up the analyses in this note after the pandemic. This would allow researchers to trace whether knowledge production has followed the global spread of the virus and whether newly hit countries relied on research conducted by the first movers (eventually teaming up with them). Further work could also allow the disentangling of different effects and explanations behind the observed shifts – namely the relevance of the inherited network structure vis-à-vis the hypothetical ‘it happened here’ and ‘rise of China’ effects. Moreover, it could also be hypothesised that the resulting knowledge production geographies will be influenced by geopolitical features, notably the attitudes of different governments towards knowledge transparency (e.g. sharing instead of closing-up information on new advances) as well as the impact of cyclical conflicts between global powers (notably the USA and China).5

Overall, understanding the shifting geographies of knowledge production systems is likely to become an increasingly relevant research endeavour, as they may signal varying (and cumulative) abilities to generate, intermediate, and access relevant knowledge in the face of epidemic outbreaks. This is a domain to which economic and social geography scholars can largely contribute, at least in three ways. First, by paying more attention to the geographies and processes involved in neglected and epidemic-related medical innovations, namely in relation to the (now well-studied) analyses of conventional drug development, pharma, medical equipment, and biotechnology. Second, instead of assuming a priori territorial boundaries and scalar approaches to knowledge and innovation, epidemic outbreaks and the networks they propel call for research that examines knowledge creation from a global perspective, in which identifying the most relevant geographies becomes an empirical question. Finally, in a time in which epidemic outbreaks may have further impacts on geopolitical structures, research on the geography of knowledge and innovation may increase its relevance by articulating its research questions with issues of power imbalances and the geopolitical dimensions that co-evolve with knowledge and technological development on a global level.

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Notes
1. Including SARS allowed research focusing on other types of coronaviruses within the same genetic family, like MERS (Middle-Eastern Respiratory Syndrome), to be captured in the results.
2. About 98 per cent of the publications under analysis (6,926 out 7,086 results) fall under the fields of medical or biological research.
3. Web of Science data was processed with Studio (RStudioTeam 2016) using the Bibliometrix...
package (Aria & Cuccurullo 2017). Resulting networks were exported in Pajek format, opened, and processed through UCINET 6 (Borgatti et al. 2002). The results were georeferenced in a GIS environment through ESRI ArcGIS (version 10.3.1).

4. We thank one anonymous reviewer for making this remark.

5. We thank the two anonymous reviewers for calling our attention to these hypotheses.

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