

Technological Cooperation, Patent, and Covid-19: A Scoping Review

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Abstract. The Covid-19 pandemic demanded a rapid response from researchers, leading to the establishment of new forms of collaboration aimed at patents and technologies. Thus, with the objective of synthesizing and analyzing the existing literature correlating technological cooperation, patents, and Covid-19, a systematic review was conducted following the PRISMA protocol, aided by the Rayyan and Atlas.ti software for article synthesis and selection. The analysis allowed for the conclusion that various forms of cooperation were established to achieve Covid-19-related innovations. It is also possible to identify shortcomings and areas for improvement in collaborations to enhance and facilitate the attainment of innovations. This article contributes by providing a systematic review of a topic of utmost international relevance (Covid-19) and by shedding light on the field of study related to technological cooperation and patents."

Keywords. Scope Review. Covid-19. Collaboration. Patent. Intellectual Property.

1. Introduction

At the end of 2019, what would become a global pandemic had its first infections caused by the new Covid-19 virus (Huang et al., 2020). By October 6, 2021, less than two years after the onset of the pandemic, more than 6 million vaccine doses had already been administered worldwide, in a scenario with over 236 million confirmed Covid-19 cases (WHO Coronavirus, 2021). At the outset of the pandemic, scholars hesitated to guarantee that solutions such as vaccines would be ready quickly. Likewise, asserting that such a solution would be available by 2021 was an extremely optimistic statement (Ball, 2021). Since the beginning of the pandemic, technologies have been developed at an extraordinarily rapid pace (Melluso et al., 2020), and the situation has spurred technological cooperation and interdisciplinarity (Delft et al., 2021).

For a successful technological innovation, the creation of bonds is necessary; isolated innovations are not easily achieved (Teece, 1992). Science tends to be increasingly collaborative, especially in situations where agility is a decisive factor; this coming together of intentions for a common goal is indispensable (Darmody & Bendis, 2021). The ways in which technological cooperations occur in such moments can undergo adjustments, as was the case

with research on Covid-19 that involved researchers from around the world, voluntarily contributing to solutions (Delft et al., 2021), many of which resulted in technological innovations protected by patents. Given this scenario, the major concern raised is: what is known from the existing literature about the relationship between technological cooperation, patents, and Covid-19?

Analyses suggest that technological cooperation is of great importance for scientific development and can be molded as the situation demands. With the Covid-19 pandemic, researchers and other actors came together in search of solutions (Abi Younes et al., 2021). However, there is no concise literature on the subject. With the aim of systematizing the existing literature on the relationship between technological cooperation, patents, and Covid-19, a scoping study was undertaken, as it is a rigorous and transparent method for mapping the chosen research area (Arksey & O'Malley, 2005). Thus, this scoping review aims to shed light on the relationships between the selected themes and allows for the analysis of texts and the quantification of important data in order to understand the interconnections arising from this relationship.

In order to achieve the proposed objective, this paper

is structured as follows: it begins with an introduction to the theoretical foundations; then, the methodological approach is presented, outlining the stages of the study's sampling process. Subsequently, the main research findings are presented, followed by the resulting implications and final considerations of the research.

2. Theoretical Foundations

Initially, it is interesting to contextualize the themes that underlie this scoping review, namely: technological cooperation and innovation. Many authors have discussed these two themes, attempting to find definitions that are broad and feasible. However, depending on the study, the involved themes, and the research context, the definition to be used tends to be adapted. In the present case, the same will occur. These definitions will guide the study.

From the connection between innovation and creativity, the creative process is established, aimed at producing a value that is negotiable and commercially exploitable. Consequently, innovation comes into play as a new or existing product, the latter having undergone improvement. Innovation, likewise, will be coupled with creativity, which will be part of its constitutive process (Taylor, 2017).

Innovation can be divided into four types, namely: radical innovation (a change that is new to the organization and serves a new group of users), expansive innovation (offering an existing product to a new group of users), evolutionary innovation (offering a new service), and developmental innovation (existing services and products are modified or improved) (Taylor, 2017; Walker et al., 2002). Regardless of which division is being referenced, there is a process that leads to innovation (Taylor, 2017), and it must be guided accordingly.

Currently, practically all Nobel Prizes are awarded not only for individual achievements but also for teamwork (Darmody & Bendis, 2021). Cooperation, in turn, can be understood for this study as alliances between partners with the aim of achieving a common goal (Zhang et al., 2010). In this sense, it is important to emphasize that collaboration allows for complementary skills to be combined, as well as cost and risk sharing (Su, 2021). Complex forms of technological cooperation will be necessary for the success of technological innovation (Teece, 1992). With the Covid-19 pandemic, coordinated efforts for effective and rapid solutions were no different and necessary (Bacq et al., 2020).

In this way, when referring to innovation and the pursuit of R&D (Research and Development) among various agents, coordination and governance are required to establish the main guidelines and regulations of the relationship (Hurmelinna-Laukkanen et al., n.d.). The need for cooperation in the pursuit of innovation is evident during crises, and cooperative forces have shaped research on Covid-19 (Abi Younes et al., 2021). Alongside this need, in

the search for cooperation and rapid actions, patent systems, catalysts for research and innovation, were questioned and raised concerns as a potential hindrance to Covid-19 research (Abi Younes et al., 2021).

3. Method

The main constructs and their variables were separated, as described below, to facilitate the identification of relevant studies (stage two) and subsequently, the selection of studies (stage 3). With the sample of studies in hand, data abstraction and mapping were carried out (stage 4) with the purpose of then comparing them and reporting the results (Arksey & O'Malley, 2005). To support the methodology, the criteria of the PRISMA - ScR (PRISMA Extension for Scoping Reviews) Protocol were also observed, with its eight criteria as shown in Table X, in order: review protocol and registration, definition of eligibility criteria for the study, selection of sources and search strategies, study selection process, data mapping, evaluation of sources of evidence, and final synthesis of results obtained, ensuring rigorous conduct of the study (Tricco et al., 2018).

3.1 Information Sources, Search Strategy, and Eligibility

Arksey & O'Malley (2005) suggest a broad definition of search terms in order to capture a wide context of research. Therefore, with the central aim of understanding the theoretical conceptual evolution from the existing literature on the relationship between technological cooperation, patents, and Covid-19, the separated keywords used were: cooperation, collaboration, network, technology, innovation, patent, covid, and coronavirus, all in English, without excluding their variations, as shown in Table 1.

Using the descriptors ("cooperat*" or "collabor*" or "network*" or "technol*" or "innovat*") and "patent*" and ("covid*" or "coronavirus"), a search was conducted on September 23, 2021, in the fields of title, abstract, and keywords, in the Web of Science and Scopus databases. The search did not impose a priori temporal or language limits. The first search yielded 290 articles, and the second yielded 148 articles, resulting in a total sample of 438.

All articles were exported from the database in RIS format. The choice of the RIS format was due to its specificity in enabling citation exchange between various software and systems. Subsequently, the content was imported into the Rayyan platform due to its ease of use.

3.2 Study Selection Process

Upon obtaining the 438 articles, a preliminary

analysis revealed a significant number of articles that were either not relevant to the study or were duplicates due to the dual databases studied. Therefore, in the initial analysis, 71 duplicate articles were identified and subsequently excluded from the sample. Upon examining the publication year, it was evident that articles published from 2004 (the first identified year) to 2018 could not be related to the research topic as they predated the 2019 coronavirus pandemic (criterion "1" for exclusion). Consequently, an additional 126 articles were excluded. Furthermore, with the assistance of keyword-based software identification, 13 literature reviews were identified and similarly excluded (criterion "2" for exclusion), along with 9 articles that were not from journals but rather conference proceedings, which were also excluded (criterion "3" for exclusion).

Next, a review of article titles was conducted to exclude those whose topics were not of interest to the current research. In cases of uncertainty, articles were retained for full abstract reading. During this analysis, articles that did not reference researcher collaboration, researcher-industry collaboration, or public-private collaboration were excluded (criterion n=4 for exclusion). Finally, two articles that were editorials were excluded (criterion "5" for exclusion). This left 18 articles within the scope for comprehensive analysis and further examination.

After a thorough reading of the texts, five articles were removed from the sample for either not correlating the cooperation construct with innovation or for merely mentioning innovation without delving into the topic. From the final body of the study, articles were read and categorized by codes using the Atlas.ti software, which were later entered for analysis and comparison in an Excel spreadsheet, separating key aspects fundamental and important for the sample analysis.

4. Research Results

Moving on to the final stage proposed by Arksey and O'Malley (2005), we proceed to the grouping, summarization, and reporting of the results.

4.1 General Characteristics of the Articles

This scoping review analyzed 12 articles that passed all exclusion criteria and remained in the final sample. The exclusion logic was driven by years due to the central theme of the study, which focused on a pandemic that initially emerged in December 2019. As a result, the samples included articles published between 2020 and 2021. All publications were distinct in terms of the journal of publication, and they are as follows, along with their impact factors (Journal Citation Reports): *Clinical Pharmacology & Therapeutics* (6.889), *Nature* (49.962), *HealthCare* (2.645), *Journal of Law and the Biosciences* (3.583), *Technology in Society* (4.192), *Biopreservation and Biobanking* (2.300), *FACETS* (2.535), *Health Affairs*,

Journal of Commercial Biotechnology (not available), *Pharmazie* (1.267), *International Journal of Biological Sciences* (6.582).

Among the 12 selected articles, six were from the year 2020, and six were from 2021. In terms of research related to the cooperation construct, only one of the studies was conducted without the presence of a co-author, namely Paradise (2020); all the others involved collaborations with other researchers.

4.2 Types of Technological Cooperation

In order to better elucidate the understanding of the scenario and concept of cooperation within the selection, an approach was defined for the topic, which was divided into direct and indirect forms of cooperation. Within the indirect approach, the works that mentioned the need for cooperation for effective and rapid R&D but did not delve into the topic throughout the work were included (Yu et al., 2020), as well as those that cited the need for data networks capable of exchanging information through a platform that would enable greater collaboration among researchers (Gao et al., 2020). Additionally, the work of Xue and Ouellette (2020) mentioned the need for financial collaboration and tax incentives to enable companies to develop vaccines but did not mention information exchange collaborations.

The forms of cooperation presented are varied and, in general, based on the premise that interactions among various agents are necessary for swift and reliable research to be carried out. The direct forms of cooperation within the article topics share the same underlying assumption.

Among the direct forms, the work of Delft et al. (2021), titled 'A white-knuckle ride of open COVID drug discovery,' confirms the importance of rapid collaborations among researchers. In this specific work, a spontaneous global collaboration took place with the aim of designing a new antiviral treatment. This cooperation between researchers, suppliers, and other stakeholders was made possible through the use and access to communication technologies that allowed interconnectivity among researchers. Driven by the clear urgency of the pandemic and not by monetary returns or personal glory, these researchers pooled their expertise through task division toward a common goal. Similar actions were also highlighted by Bubela et al. (2021), where open data, driven by philanthropy, positively aided research.

Furthermore, the role of the government as a governmental agent capable of fostering and incentivizing R&D proves to be of great value. Paradise (2020) and Liu et al. (2021) share the conception that the relationship between academia and government is important in ensuring that collaborations are effective. The former possesses the necessary know-how for research to take place, while the latter acts as an agent capable of providing monetary and political incentives for research. In

similar abstractions, Peck et al. (2020), Xue & Ouellette (2020), Sampat & Shadlen (2021), and Yu et al. (2020) in their research demonstrate how the government-business relationship must be established with caution and political rigor to maintain a healthy balance between commercial interests and collective interests.

The aforementioned text by Delf et al. (2021) showed in practice how a global cooperation occurred in pursuit of an antiviral treatment during the Covid-19 pandemic. As Lee et al. (2020) emphasizes, there is also a need to establish international cooperation strategies that endure, and the author highlights the importance of investigating the status quo of R&D to chart such courses.

In line with Gao et al.'s (2020) perspective, a data-sharing system for research is of utmost importance. Decentralization of data is driven by factors such as legal considerations, security, financial aspects, and standardization, which hinder the possibility of collaborations. The article in question also proposes ways to address this need.

The exchange of information is of such importance that Darmody & Bendis (2021) base their work on reports of regions that support the growth of regional innovation clusters capable of bringing together researchers, leaders, funding, and neutral intermediaries who, in the course of innovation incentives, can generate technologies at an accelerated pace. According to the authors, science is increasingly collaborative, and the efficiency and effectiveness of geographical groupings, or clusters, are recognized. The work also discusses areas focused on bioscience, where this statement holds true when supported by six growth factors: strong leadership, significant company engagement, talent allocation, access to capital, research facilities and resources, and, finally, marketing and awareness of the local brand.

Liu et al. (2021) further emphasizes the importance of understanding the global cooperative innovation system in relation to human coronaviruses so that researchers and policymakers worldwide can comprehend the landscape.

Given the global impact of the current pandemic situation, a systematic characterization of technological knowledge production is of crucial interest for understanding the global innovation system related to human coronaviruses and informing researchers and policymakers worldwide. By characterizing the global landscape of technological knowledge production, innovation research informs us that patents are a highly promising indicator, as they provide systematic information about new technological knowledge disaggregated by very detailed hierarchies of technological fields and attributed in geographical and temporal contexts.

4.3 Types of Innovation

Tables The innovation construct is addressed by several authors in both direct and indirect ways. Zimmerling & Chen (2021) adopted innovation in their study as a creative response that requires resources to enable the development of products or processes. This is a direct definition, as their work provides an overview of innovative procedures and technologies that were implemented during the pandemic. The authors' intention was to conduct an analysis of the social impact of these innovations over time.

In contrast, works such as those by Peck et al. (2020), Delf et al. (2021), Lee et al. (2020), and Gao et al. (2020) correlated their research with constructs of patents, intellectual property, and/or technologies. Therefore, the initial definition of the concept to be adopted for the scoping review analysis was of utmost importance, as it required an abstraction of what the authors were referring to with the innovation process. These three terms are references to understanding and comprehending innovation, with the first two being more explicit, as noted by Sampat & Shadlen (2021), where patents are significant incentives for innovation. When the author mentions intellectual property, it is understood that there is a focus on the realms of patents and software within this broad field, and thus, innovation is similarly perceived.

On the other hand, research by Bubela et al. (2020), Darmody & Bendis (2021), Paradise (2020), Xue & Ouekkette (2020), and Yu et al. (2020) directly mentioned innovation in various aspects, sometimes correlating it with intellectual property, especially patents, but did not define it explicitly. Liu et al. (2021) mentions the innovation construct but correlates it with patents, arguing that they are promising indicators and provide systematic and detailed information. The work of Liu et al. (2020) falls in line with this approach.

Sampat & Shadlen (2021) brought an interesting approach to the Covid-19 innovation system, correlating it with public policy, particularly in the United States. They conducted an assessment of the key characteristics of this system to better understand the actors (both public and private) that influence the development and constant diffusion of these pandemic-fighting innovations and technologies.

5. Conclusions and Limitations

The study began with the inquiry into collaborations for research related to the Covid-19 pandemic. It is evident that collaborations existed for the development of innovations, but, likewise, the shortcomings arising from them, as well as the lack of efficient global organizations, were highlighted.

From the study, it is possible to recognize the importance of cooperation in terms of information exchange among researchers for rapid and effective research, as the pandemic situation demanded. It was also inferred the need for a governmental figure

capable of directing research, fostering it, and acting as an effective regulator for both business interests and those of the state as representatives of the people.

This study has limitations in terms of its temporal approach, as the pandemic was still ongoing when the data base was generated, and as a result, research, collaborations, and innovations will continue to occur. Further updates are necessary to identify new additions, abstractions, and forms of cooperation.

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7. References

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