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International R&D Collaboration in Response to Global Disruptions: A Comparative Bibliometric Analysis of Research Networks

Marzenna Anna Weresa https://orcid.org/0000-0003-3112-3460
Professor, SGH Warsaw School of Economics, World Economy Research Institute, Warsaw, Poland, corresponding author, e-mail: mweres@sgh.waw.pl

Artur F. Tomeczek https://orcid.org/0000-0003-4888-2535
Assistant Professor, SGH Warsaw School of Economics, World Economy Research Institute, Global Economic Interdependence Department, Warsaw, Poland, e-mail: artur.tomeczek@sgh.waw.pl

Abstract

This study examines the international research and development (R&D) collaboration related to global crises or disruptions, focusing on its role in addressing challenges arising from diverse crises. Bibliometric analysis of 160 peer-reviewed articles identified patterns of collaboration and mapped global research networks. We adopted a comparative analytical framework to examine differences in research collaboration focus and forms across multiple types of disruption or crisis. The results show that R&D collaboration related to disruptive events was concentrated in research centers such as the United States, the United Kingdom, and Germany, with the strongest links between the United States and China and between China and the United Kingdom. Other countries occupy more peripheral positions in global collaboration networks, reflecting lower overall engagement in research on the topic. In Central and Eastern Europe (CEE), Czechia stands out as one of the few countries whose research activities on collaboration during turbulence are internationally visible. Existing networks of connections between research centers are mostly bilateral, with researchers from CEE and the Global South being underrepresented. Furthermore, six thematic areas related to crises emerged as focal points for R&D collaborations: environmental crises, health emergencies, technological change, economic shocks, institutional instability, and humanitarian challenges. By identifying patterns of international R&D collaboration related to destabilizing events, the results of the analyses may inspire more effective responses to global challenges and support the development of more resilient and crisis-responsive R&D strategies.

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Introduction

Over the past two decades, the global economy has been repeatedly shaken by major crises, beginning with the 2008 Great Recession and culminating in the COVID-19 pandemic. These events disrupted socio-economic systems worldwide and underscored the need for coordinated scientific efforts across borders. The COVID-19 pandemic, in particular, highlighted the critical role of international research collaboration in generating rapid and impactful solutions (Guimón and Narula 2020; Lee and Haupt 2021a). Yet crises are not solely destructive – they also create valuable opportunities for learning and innovation. In this context, research and development (R&D) collaboration becomes an essential tool. Through co-creation, knowledge sharing, and technology transfer, collaborative R&D facilitates the development of new innovative solutions to complex global problems.

As economic systems have become more interconnected, international research collaboration has gained growing significance. This form of cooperation encompasses partnerships among multinational corporations, universities, and research institutions across national boundaries (Belderbos et al. 2014; 2022; Du, Leten, and Vanhaverbeke 2014; Fu and Li 2016; Suzuki, Belderbos, and Kwon 2017; Yoon, Yang, and Park 2017; Hurtado-Torres, Aragón-Correa, and Ortiz-de-Mandojana 2018; Gretsch, Salzmann, and Kock 2019; Zhang, Chen, and Fu 2019; Belderbos, Park, and Carree 2021; Fu et al. 2021; O'Dwyer, Filieri, and O'Malley 2022). At the same time, protectionism, geopolitical tensions, wars, and rising security concerns increasingly threaten the openness, trust, and researcher mobility required for sustained collaboration. On the other hand, these crises can constrain international R&D collaboration by introducing political barriers, shifting national priorities, or altering the dynamics of who collaborates with whom and which topics receive attention.

Although international collaborative research is widely recognized for its benefits – such as knowledge sharing, learning effects, and technology transfer – there is still limited understanding of how collaboration evolves in response to global disruptions. This article addresses that gap through a bibliometric review of 160 peer-reviewed articles, complemented by a systematic assessment of collaboration patterns. We analyze who is studying international R&D collaboration, how networks are structured, and which themes dominate the literature. We also identify underexplored areas that represent critical gaps in current research. By doing so, the study provides researchers and practitioners in diverse development contexts with evidence to design more inclusive, resilient, and context-sensitive responses to disruption.

The study is guided by the following research questions: **How has existing research explored R&D collaborations focused on finding solutions to disruptive events or crises? What key themes have emerged, and what research gaps remain in the current literature?** Based on these questions, the study pursues the following objectives:

- To map the scientific literature on international R&D collaboration under conditions of uncertainty;
- To identify the geographic distribution and intensity of collaborative research networks;
- To classify the dominant areas of crisis-related R&D activity and group them into thematic clusters;
- To evaluate intellectual trends and identify future research directions, particularly in relation to innovation systems, cross-border knowledge flows, and institutional asymmetries.

Using bibliometric methodology, we trace collaborative publishing patterns and examine how researchers have jointly responded to various crises and disruptions. By applying co-authorship (Newman 2001; Janssen et al. 2006; Becken 2013; Mokhtari et al. 2020; Bengoa et al. 2021; Cerver Romero, Ferreira, and Fernandes 2021; Gao et al. 2022; 2023) and co-occurrence network analyses (Li et al. 2021; Yalcin and Daim 2021; Daim and Yalçın 2022; Fernandes and Ferreira 2022; Tomeczek 2022; Wang et al. 2022; Yadav, Kumar, and Malik 2022), we quantitatively show the responses to specific types of crises. To enrich the bibliometric findings, we also draw on a systematic literature review to reveal patterns of international R&D collaboration during times of disruption, as well as the key themes and focal areas explored within the existing body of development research.

This paper is organized into six sections. Section 2 reviews the literature on international research collaboration and crises. Section 3 outlines the methodology. Section 4 presents the results: subsection 4.1 maps the geographic distribution of research networks and knowledge flows, while subsection 4.2 identifies the key thematic clusters. Section 5 discusses the findings, and Section 6 concludes.

Literature review

Conceptualization and measurement of research collaboration

Studies on research collaboration have been conducted for several decades; however, the development of information and communication technologies, the growth of internationally funded projects, and the rise of global challenges requiring joint scientific efforts have made such collaboration increasingly international. Patel (1973) defines research collaboration as a process of generating new knowledge through the integration of efforts by individual researchers. International research collaboration has emerged as a significant area within innovation studies. It is broadly defined as collaborative projects involving researchers affiliated with institutions in different countries (Anderson and Steneck 2010; Wagner, Whetsell, and Mukherjee 2019). Some scholars have extended this definition to emphasize the output dimension, arguing that research collaboration is conducted to advance scientific knowledge, which includes knowledge transfer and application, and eventually leads to practical implementation (Yao 2021).

The open innovation framework (Chesbrough 2003; 2024) conceptualizes R&D collaboration as a deliberate strategy for integrating internal and external knowledge flows. From the perspective

of resource dependence theory, organizations that control critical resources (e.g., funding, infrastructure, and specialized expertise) exercise disproportionate influence over the terms, structure, and governance of collaborative relationships (Pfeffer and Salancik 1978; Drees and Heugens 2013). Open innovation emphasizes the strategic integration of internal and external knowledge flows, while resource dependence theory draws attention to how unequal access to critical resources influences interorganizational relationships. In this context, the importance of governance structures and power relations in shaping collaborative outcomes must be highlighted. Gray, Purdy, and Ansari (2022) highlighted that partnerships addressing complex societal problems (i.e., grand challenges) often fall short when power differences among actors are not adequately addressed. Ruangpermpool, Igel, and Siengthai (2020) indicated that balanced formal and informal governance supports the commercialization of research in university–industry collaboration. Case-based research of power asymmetries conducted by Macaulay (2025) demonstrated how imbalances can shift over time within interorganizational partnerships, affecting collaboration dynamics and the capacity for joint action.

Taken together, these theoretical perspectives and empirical findings suggest that successful R&D collaboration depends not only on the integration of diverse knowledge sources but also on the distribution of resources, which may be related to the geographical configuration of partner organizations, management of collaborative relations, and broader contextual factors.

In general, collaborations between researchers are typically documented through scientific publications that are co-authored by scholars from different scientific institutions or the analysis of patent collaborations (Ye, De Moortel, and Crispeels 2020; Tsouchnika et al. 2022). Many studies use co-authorship as the primary indicator of scientific collaboration (e.g., Patel 1973; Pao 1992; Wagner, Whetsell, and Mukherjee 2019; De Stefano et al. 2023), acknowledging, however, that it is not the only measure of collaborative R&D efforts, as it captures only a part of research collaboration. Other measures include joint research projects, co-patenting, and cooperative R&D agreements (Bozeman and Boardman 2014; Amoroso, Coad, and Grassano 2018), as well as the extent of knowledge sharing, the scope of technology transfer, and the sustainability of collaboration efforts (Philbin 2008). The methods for measuring international collaboration are still evolving and have not yet reached full standardization (Chen, Zhang, and Fu 2019).

The intensity of collaboration varies significantly across scientific disciplines. In some fields, such as science, technology, engineering, and mathematics (STEM), over 90% of research projects and publications are carried out in collaboration, which leads to a "collaboration imperative" (Bozeman and Boardman 2014). Overall, the level of scientific collaboration has shown a consistent upward trend over time (Wagner, Park, and Leydesdorff 2015).

Bibliometric analysis offers quantitative tools to assess large volumes of scientific output (Chen, Zhang, and Fu 2019; Wagner, Whetsell, and Mukherjee 2019), which may capture collaboration patterns across individuals, institutions, and countries, reflecting changes linked to globalization and shifts in scientific communication (Glänzel and Schubert 2005). It is worth noting that bibliometric methods can also be used in the analysis of patents (Tomeczek 2025). Network analysis of patents is related to technological profiles and capabilities of firms and other institutions (e.g., universities). Bibliometric analysis systematizes and maps

knowledge regardless of whether it is applied to scientific publication data or patent data. Furthermore, previous keyword co-occurrence bibliometric analysis of open innovation and university-industry collaboration identifies five thematic clusters related to technology transfer, university-industry knowledge transfer, academic entrepreneurship, knowledge exchange, and universities (Ballesteros-Ballesteros and Zárate-Torres 2025). Another bibliometric study of innovation intermediaries reveals clusters related to innovation performance, knowledge networks, and technology transfer (Zhang and Liu 2024). Lattu and Cai (2023) highlight six institutional logics: state, market, corporation, profession, traditional trust-based community, and sustainability-based community. Researchers increasingly apply institutional logics to understand how norms, values, and governance systems influence university-industry collaboration patterns.

Overall, the literature shows that research collaboration is a multidimensional phenomenon that can be anchored in the open innovation concept and aims to advance scientific knowledge through the integration of talents and resources while taking diverse forms. Theoretical perspectives indicate that R&D collaboration can be shaped by knowledge integration, access to critical resources, and power relations among partners. The open innovation framework highlights the importance of combining internal and external knowledge, while resource dependence theory explains how control over key resources influences collaborative governance. This integrated perspective also encompasses selected knowledge management-related issues, such as knowledge flows and spillovers, as they are embedded in broader innovation and collaboration processes and, to some extent, reflected in the empirical findings analyzed above. Existing studies (e.g., Gray, Purdy, and Ansari 2022; Macaulay 2025) suggest that unbalanced power relations can weaken partnerships, while appropriate governance arrangements may support effective and sustainable collaboration.

It also should be pointed out that collaborative efforts cannot be fully captured by any single indicator. Co-authorship or co-patenting are commonly used measures of research collaboration, and although studies typically rely on one of these indicators depending on data availability and research focus, their inherent limitations should be carefully acknowledged and considered in interpretation. This study follows this approach.

Global disruption and R&D collaboration

It is widely acknowledged that crises and disruptions introduce new risks and challenges that are too complex to be addressed in isolation. Therefore, questions remain about how this imperative for R&D collaboration functions during periods of disruption or crisis, particularly whether it develops at local or global levels. Such contexts call for multi-organizational collaboration in risk management and coordinated responses to extreme events (Kapucu, Arslan, and Collins 2010). Effectively navigating critical tasks requires collaborative capacity, that is, the ability to integrate, generate, and apply new knowledge under pressure in order to innovate and find solutions to complex problems (Weber and Khademian 2008). Furthermore, Rani et al. (2025) emphasized the strategic role of digitalization and green technologies in promoting collaboration within the BRICS-T economies.

There is also a growing body of literature on international scientific collaboration during the COVID-19 pandemic, which has confirmed a rise in "scientific globalism" as a response to the crisis (e.g., Cai, Fry, and Wagner 2021; Lee and Haupt 2021b; OECD 2021; Abramo, D'Angelo, and Di Costa 2022). According to these studies, engagement in international collaboration during crises depends on several factors, including the severity of the crisis and a country's level of development. Shih, Chubb, and Cooney-O'Donoghue (2024) showed that intensifying geopolitical tensions, particularly those involving China, have prompted countries such as Australia and Sweden to redesign risk-management protocols and funding guidelines for international collaboration. Wagner and Cai (2022) identified an emerging decline in China-USA co-publications from 2020 onward, suggesting that the pandemic triggered a broader shift in collaboration dynamics. In contrast, ties between China and Europe or the USA and Europe remained relatively stable, highlighting how the pandemic selectively reshaped global research networks rather than uniformly weakening them. These findings indicate that R&D collaboration may either increase or diminish in times of disruption, depending on contextual factors.

War and geopolitical tensions can sharply reduce scientific output and weaken international collaboration networks. For instance, Russian research productivity in Web of Science-indexed journals has decreased since 2022, following years of growth prior to the war (Zhang et al. 2024). Similarly, Ukrainian research networks experienced a reduction in collaboration diversity in 2022 due to institutional damage and loss of research capabilities (Damaševičius and Zailskaitė-Jakštė 2023). A comprehensive econometric analysis found that EU-Russia co-publication rates significantly declined since 2014 due to sanctions and counter-sanctions, before their total suspension in 2022 (Makkonen and Mitze 2023). The EU's suspension of Russia from Horizon Europe in 2022 reflects a shift toward selective closure in international research collaboration (Bamberger and Huang 2025). After the full-scale invasion, Russia experienced significant declines in publication activity linked to restricted funding, reduced mobility, and loss of access to international research infrastructures (Kozmenko et al. 2025). According to Zhang et al. (2024), domestic policy changes, such as the termination of the academic excellence initiative "Project 5top100", may have played an even greater role in isolating Russian science and its long-term collaboration declines.

Damaševičius and Zailskaitė-Jakštė (2023) showed how war-related crises, such as the conflict in Ukraine, led to a decline in international output for some regions, thereby providing evidence that the nature of the crisis – whether health-related, political, or economic – can shape collaborative trajectories differently. These contributions underscore the need to understand collaboration not only as a reactive mechanism during crises but also as a strategic response to crises shaped by technological, political, and institutional capacities.

Given the inconsistent patterns of collaborative R&D reported in the literature, there is a clear need to systematically analyze studies in the social sciences that explore research collaboration during periods of disruption and uncertainty caused by various types of crises. This paper aims to address that gap by uncovering patterns, themes, and underexplored areas of international R&D collaboration in crisis contexts.

This study focuses specifically on R&D collaboration related to the context of crises, disruptions, and unexpected events. While international research collaboration is a broad phenomenon, our analysis is limited to those collaborative efforts that explicitly address disruptive challenges, such as natural disasters, pandemics, geopolitical conflicts, and other forms of crisis and uncertainty. We do not examine R&D collaboration in general, but rather the subset of literature that explores how researchers work together across borders in response to, or in anticipation of, such events. Our aim is to examine how existing research in economics and business has addressed R&D collaborations in response to disruptive events or crises, and to identify and compare key thematic areas, revealing remaining research gaps in the literature. This targeted approach, focusing on country-level co-authorship, allows us to contribute to understanding in which countries researchers are most intensively studying R&D collaboration in the context of crises, whether and how researchers from different countries collaborate on these studies, and what networks are formed, which specific aspects are being investigated, and which areas remain critically underexplored.

Methods and data

To identify how patterns of R&D collaboration related to crises and disruptions have evolved, we apply bibliometric analysis – a robust, data-driven approach for uncovering key research patterns and trends. Bibliometrics has developed significantly over the decades, gaining prominence through the seminal work of Garfield (1995) and the influential contributions of the 1960s (Kessler 1963; de Solla Price 1965).

To explore the geographical patterns of researchers' affiliations, they are aggregated at the level of countries or territories. Additionally, to complement the country profiles of researchers actively publishing on R&D collaboration in the context of crises or disruptions, we identify co-authorship networks to illustrate how research teams are formed to study this topic. Co-authorship networks represent authors (nodes or vertices) and the co-authorships of scientific documents (edges or links).

To contribute to understanding which topics are most frequently explored and where gaps remain in the literature, we apply a keyword co-occurrence network that enables the knowledge mapping of existing research.

Keyword co-occurrence networks represent keywords (nodes or vertices) and their co-occurrence in scientific articles (edges or links). This type of analysis can illustrate thematic clusters and trends within a body of scientific literature. Methodologically, some degree of keyword standardization might be necessary for this type of bibliometric analysis, as otherwise, synonymous keywords can dilute the results (Lee and Su 2010; Li et al. 2016; Kiani Mavi et al. 2021). The articles collected for this analysis require data normalization. Standardization included aligning plural and singular forms (e.g., "collaborations" and "collaboration"), abbreviations (e.g., "R&D" and "research and development"), and synonyms (e.g., "coronavirus" and "COVID-19"), consistent with previous bibliometric studies. The most dominant keyword, "research collaboration," aggregates 28 related terms, such as "co-research," "international

research," and "R&D collaboration." In total, 153 keyword groupings were made for keyword analysis and the identification of thematic clusters.

To better understand the structure of scientific knowledge and reveal how research themes are organized and interconnected, we applied modularity analysis. This network analysis method identifies clusters or "communities" within a network – groups of nodes (in this case, keywords) that are more densely connected to each other than to the rest of the network.

The identified thematic clusters are further examined through a systematic literature review, which, according to the methodological guidelines outlined by Kraus et al. (2022), is well-suited for domain-focused reviews in specific research fields.

We used the Scopus database to collect our data. Network construction and visualizations are carried out using Gephi software, a widely used tool for network analysis. The steps of the systematic literature selection process are outlined in Table 1. A common practice in bibliometric analyses, particularly for keyword co-occurrence networks, is to focus on peer-reviewed scientific articles (Moody 2004; Li et al. 2021; Wood et al. 2021; Bhandal et al. 2022; Corrêa et al. 2022; Fernandes and Ferreira 2022; Gao, Lin, and Lu 2022; Healy, Hammer, and McIlveen 2022; Oliveira, Carvalho, and Reis 2022; Xu, Hou, and Wang 2022; Yadav, Kumar, and Malik 2022; Zhao and Strotmann 2022; Kryszak, Świerczyńska, and Staniszewski 2023; Nazzal, Sánchez-Rebull, and Niñerola 2023; Pennetta, Anglani, and Mathews 2023), and we followed this approach in our study. The search query was designed to include synonyms and wildcard variations of "disruption," and synonyms and wildcard variations of "scientific collaboration." The query resulted in 1,020 publications that analyze scientific collaboration related to crises and periods of uncertainty. Additionally, we limited the results to English-language literature in the social sciences and related disciplines. After cleaning the data (removing irrelevant articles and those with missing keywords), we were left with 160 scientific articles. In recent years, both the world and the nature of crises it faces have changed rapidly. The period analyzed in this article is bookmarked by the COVID-19 pandemic and its aftermath. The pandemic was a monumental short-term shift in global production with long-term geopolitical consequences. The analysis of future crises and uncertainty, likely related to the reshoring of global value chains and the widespread adoption of AI technologies, can both learn from the past and provide new insights that should be explored in future studies.

Table 1. Systematic literature selection (conducted in Scopus database, 1975–2023)

Step	Search query string	Results
1	TITLE-ABS-KEY ("uncertaint*" OR "disrupt*" OR "unpredict*" OR "imperfect information*" OR "information asymmetr*" OR "external shock*" OR "crisis") AND TITLE-ABS-KEY ("scientific collaborat*" OR "academic collaborat*" OR "research collaborat*" OR "development collaborat*" OR "R&D collaborat*" OR "collaboration in science" OR "collaboration in academia" OR "collaboration in research" OR "collaboration in development" OR "collaboration in R&D" OR "scientific network*" OR "academic network*" OR "R&D network*" OR "research and development network*" OR "scientific cooperat*" OR "academic cooperat*" OR "research cooperat*" OR "development cooperat*" OR "R&D cooperat*" OR "scientific co-operat*" OR "academic co-operat*" OR "research co-operat*" OR "development co-operat*" OR "R&D co-operat*" OR "scientific consortium*" OR "academic consortium*" OR "research consortium*" OR "development consortium*" OR "R&D consortium*" OR "international research and development" OR "international R&D" OR "global research and development" OR "global R&D" OR "collaboration analysis" OR "collaboration network" OR "co-authorship analysis" OR "coauthorship analysis" OR "co-author analysis" OR "coauthor analysis" OR "co-authorship network" OR "coauthorship network" OR "co-author network" OR "coauthor network" OR "patent analysis" OR "patent network")	1,020
2	published in English	975
3	research articles and review articles	690
4	subject areas (Business, Management, and Accounting; Economics, Econometrics, and Finance; Social Sciences; Decision Sciences)	375
5	cleaning the data	160

Source: authors' elaboration.

Results

The research landscape on crisis-driven R&D collaboration

Research on international R&D collaboration in the context of crises and disruptions is predominantly conducted by scholars affiliated with the United States (36 articles), China (24 articles), and the United Kingdom (20 articles), which in our sample have the highest number of co-authors originating from these countries and publishing on this topic. These countries not only contribute the largest volume of publications but also form the core of international co-authorship networks studying this topic, as reflected by their large node sizes and dense interconnections in the network visualization (Chart 1). The United States stands out as the leading actor, with strong collaborative ties to both European and Asia-Pacific countries, including links with China, the United Kingdom, and Australia. Some other countries, such as the United Kingdom and Germany, also play important roles, serving as key connectors within European and transatlantic collaborations, with the United Kingdom acting as a central bridge between North American, European, and Asia-Pacific partners. In contrast, countries such as Italy, Greece, South Africa, Malaysia, and Czechia appear at the periphery, indicating lower levels of engagement in research on this topic (Chart 1), as evidenced by their smaller node sizes and limited number of collaborative ties. Other countries from Central Europe occupy more peripheral positions in global collaboration networks, reflecting lower overall engagement

in research on disruptions and crisis-related topics. It may be associated with structural constraints such as more limited research funding, weaker integration into international research consortia, and reduced access to global scientific infrastructures as documented by policy studies (European Parliamentary Research Service 2018; European Commission 2025).

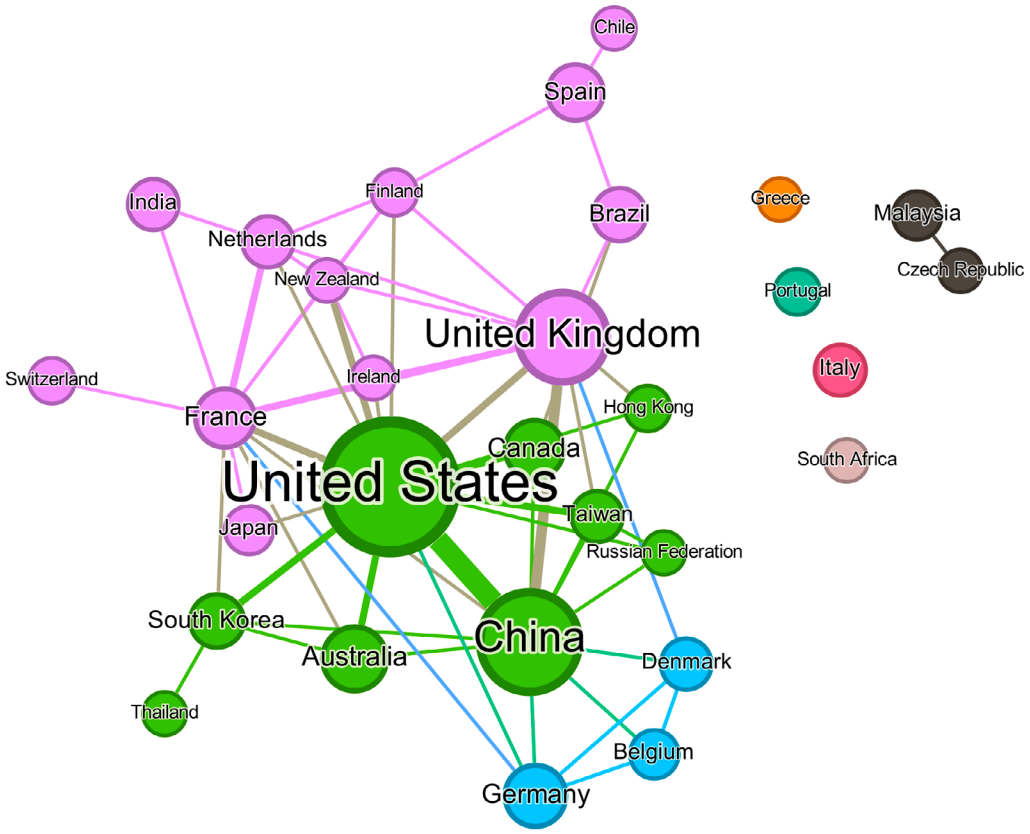

Chart 1. Geographical distribution of authors studying international R&D collaboration in the context of crises, and their scientific networks (size: occurrence count, color: modularity class)
Source: authors' elaboration.

Overall, the authorship structure of the papers highlights a concentration of research efforts in high-income countries, with notable gaps in cross-regional participation, including the region of Central and Eastern Europe.

Mapping knowledge and emerging research hotspots

This subsection presents the knowledge map and identifies the key research topics addressed by authors publishing on international R&D collaboration in the context of crises and disruptions.

Chart 2 illustrates the communities in the keyword co-occurrence network, revealing distinct thematic clusters within the literature on international R&D collaboration in the context of crises and disruptions.

The keyword co-occurrence network shows that keywords can be grouped not only by research topics but also by methods applied. The key methods include bibliometric analysis, patent analysis, social network analysis, and cluster analysis, highlighting the diverse methodological

approaches used to examine R&D collaboration. Bibliometrics has seen a surge in popularity, particularly as the COVID-19 pandemic underscored the need to organize and systematize rapidly expanding scientific output. Bibliometric and scientometric approaches play an integral role in studying collaboration, as shown by the prominent cluster containing general methodological terms (e.g., "bibliometric analysis" and "scientometrics"), analytical methods (e.g., "co-authorship" and "co-citation analysis"), and tools (e.g., "Scopus," "VOSviewer," and "CiteSpace") occurring as keywords in some publications (e.g., Sahil and Sood 2021; Vong, Rita, and António 2021; Castelló-Sirvent and Roger-Monzó 2022; Sardana and Singhania 2022).

The keyword co-occurrence network (visualized in Chart 2) further shows relatively strong linkages between bibliometric analysis, co-authorship, and co-citation analysis, indicating that publication-based indicators remain the dominant tools for studying collaborative structures. Furthermore, patent analysis is closely linked with social network analysis and technology-related keywords, reflecting the frequent use of patent data to examine technological collaboration and relational dynamics. Overall, the co-occurrence structure suggests that quantitative, data-driven approaches form the methodological core of the field, with standardized bibliometric databases and software further reinforcing this orientation. At the same time, the relatively limited visibility of qualitative or mixed-method approaches indicates that they remain underrepresented, pointing to an ongoing methodological bias toward large-scale, data-driven research designs in this field (Chart 2).

Based on the keyword co-occurrence network (Chart 2), we also observe how scientific themes are organized and interconnected, allowing for the detection of both dominant research areas and emerging hotspots.

A significant shift toward pandemic-related research is visible in the network, with the COVID-19 crisis driving an unprecedented increase in collaborative activity. The global nature of the pandemic demanded unorthodox and accelerated responses, reflected in intensified international co-authorship and the development of adaptive collaborative frameworks (Belli et al. 2020; Wu et al. 2021; Abramo, D'Angelo, and Di Costa 2022; Damaševičius and Zailskaitė-Jakštė 2022).

Our review of selected articles reveals a diversity of collaborative themes shaped by different types of disruption. Some studies aim to address the practical challenges of crisis response, while others focus on mapping R&D collaboration in fields impacted by specific crises, such as global health (e.g., cancer or the Zika virus) (Sampaio et al. 2020; Kameda et al. 2021), technological uncertainty, or environmental instability. Several contributions also explore the geographic dimensions of collaboration (e.g., Orecchini, Valitutti, and Vitali 2012; Banerjee and Siebert 2017; Rocha et al. 2022) and the influence of disruptions on scientific mobility and partnership stability (e.g., Zhao, Bu, and Li 2022).

A large number of studies present in-depth case analyses of R&D collaboration during specific crises, ranging from the water crisis in Nepal (Pandey and Bajracharya 2017) to strategic alliances in pharmaceutical development, such as the collaboration between Pfizer and Bristol-Myers Squibb (Tian, Gurnani, and Xu 2021). Others take a broader perspective, linking scientific cooperation with geopolitical dynamics amid global threats (e.g., Lee and Haupt 2021b). To better

identify thematic concentrations, we excluded the generic keyword "research collaboration" from modularity analysis, as it appeared in every article due to our selection criteria.

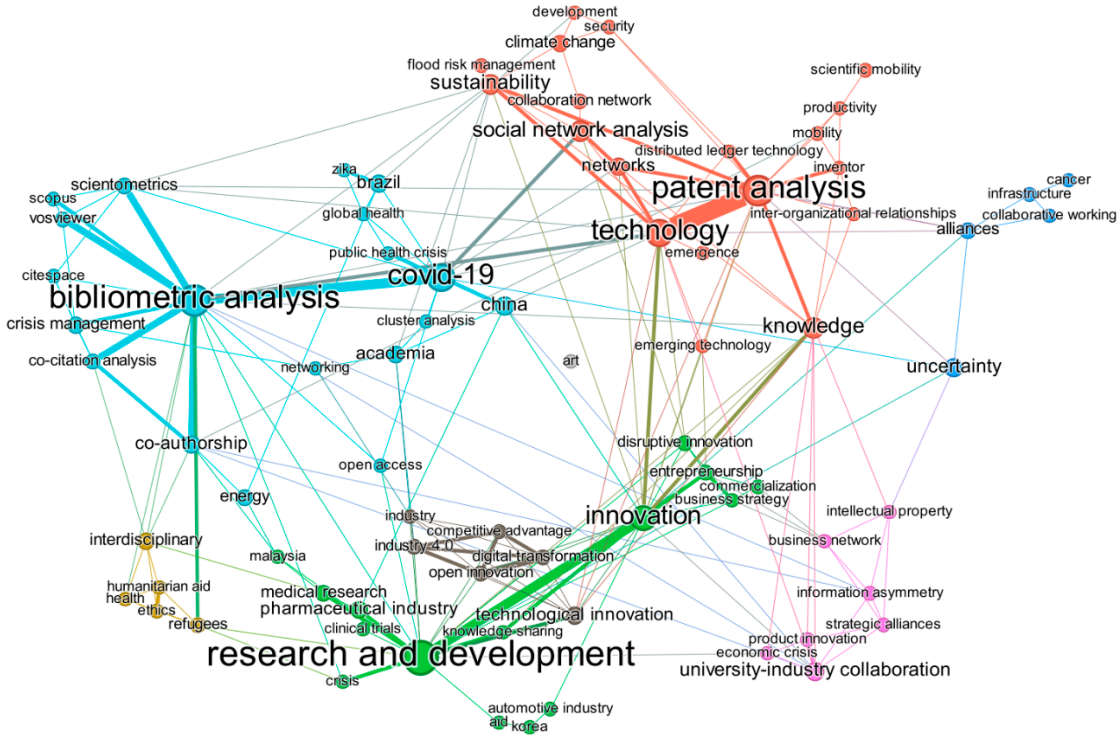

Chart 2. Keyword co-occurrence network excluding keyword "research collaboration" (size: occurrence count, color: modularity class)
Source: authors' elaboration.

Based on the types of disruptive factors, six thematic clusters emerge from the keyword network analysis of the analyzed sample of publications on research collaboration in contexts of disruption or uncertainty. These thematic clusters indicate that research collaboration varies depending on the specific types of uncertainty arising from:

1. **Environmental disruption** (Cluster 1): this cluster includes themes such as sustainability, climate change, and security, with "networking" frequently appearing as a key mode of collaboration.
2. **Global health crisis** (Cluster 2): dominated by research related to COVID-19 and other health emergencies, this cluster also emphasizes the role of academia and international networks in responding to global health threats.
3. **Technological disruption** (Clusters 3): this cluster focuses on digital transformation, open innovation, and disruptive technologies, particularly in the medical and pharmaceutical sectors, highlighting the important role of industry in collaborative R&D efforts.
4. **Financial and economic crisis** (Cluster 4): topics include university–industry collaboration, product innovation, and the influence of economic instability on patterns of research cooperation.

5. **Institutional disruption** (Cluster 5): this cluster explores how alliances and collaborative working arrangements are shaped by uncertainty and instability in institutional environments.
6. **Humanitarian crisis** (Cluster 6): encompassing issues such as ethics, health, and refugee-related research, this cluster underscores the interdisciplinary nature of collaboration in response to humanitarian emergencies.

Research themes, knowledge gaps, and collaboration types

The keywords grouped in each cluster not only define thematic scopes but also indicate the types of actors engaged in R&D collaboration, ranging from science–science partnerships to science–business–government consortia. Together, these clusters illustrate that R&D collaboration during crises is not monolithic but adapts to the type of uncertainty experienced, producing differentiated patterns of partnership, knowledge exchange, and innovation across contexts. Table 2 provides a detailed overview of each cluster, highlighting frequently addressed research topics, key contributors, representative case studies, and suggested directions for future research.

Table 2. Research Themes on R&D Collaboration Amid Crises

Type of crisis/ disruption	Number of occurrences	Hot topics/areas of collaboration studied in the papers	Authors of the top 3 most cited papers	Type of collaboration	Key findings	Future research directions indicated by the authors
Environmental disruption	**88**	**Sustainability, security, climate change, inventor**	Gaziulusoy et al. (2016)	Science-science (transdisci-plinary research collaboration)	Environmental disruption requires transdisciplinary collaborative research projects. Emergent responses in management, with leadership playing a mediation role, are necessary. Research teams should be co-located and/or trained to facilitate team development.	Not indicated
			Orecchini, Valitutti, and Vitali (2012)	Science–business	The crisis in sustainability requires the intensification of industry–academia collaboration and more entrepreneurial behavior of universities.	Structuring conceptual scientific methods for knowledge exchanges between industry and science.
			Pandey and Bajracharya (2017)	Science–business–citizens	The example of the water crisis in Nepal shows that broad collaboration between research teams and stakeholders can reduce uncertainty and support more sustainable urban water management.	Studying innovative methods of participatory and collaborative research.

Type of crisis/ disruption	Number of occurrences	Hot topics/areas of collaboration studied in the papers	Authors of the top 3 most cited papers	Type of collaboration	Key findings	Future research directions indicated by the authors
Global health crisis	**87**	**COVID-19, crisis management**	Lee and Haupt (2021b)	Science–science	The COVID-19 crisis intensified international research collaboration, especially on pandemic-related topics. Yet, the extent of this increase varied markedly across countries, revealing uneven patterns of collaborative engagement during the pandemic.	Research on the interdependencies between scientific collaboration and geopolitical rivalry.
			Kim and Cho (2021)	Science–science	The importance of international research collaboration during the COVID-19 pandemic varied across countries, with the United States and Europe collaborating more intensively than Asian countries. Some countries (e.g., Belgium and Pakistan) expanded their research interests through collaboration. Medicine was the predominant research area.	Research on the differences between the impacts of journals and articles.
			Nguyen et al. (2021)	Science–science	International research collaboration during the COVID-19 pandemic varied significantly across countries, with the United States and Europe collaborating more intensively than Asian countries. Some countries (e.g., Belgium and Pakistan) broadened their research agendas through collaboration, and medicine emerged as the predominant field.	Further development of collaborative studies to address mental health issues.

Type of crisis/ disruption	Number of occurrences	Hot topics/areas of collaboration studied in the papers	Authors of the top 3 most cited papers	Type of collaboration	Key findings	Future research directions indicated by the authors
Technological disruption	**83**	**Digital transformation, open innovation, industry 4.0; disruptive innovation in the medical & pharmaceutical sector**	Baba and Walsh (2010)	Business–science–government	To be successful in disruptive technology development and breakthrough innovations that are new to the world but risky, companies must have: 1. capabilities to access new external knowledge from beyond the firm, and 2. social capital in industry, academia, and government that can be used for collaboration.	Comparative research on the conditions that lead to the creation of breakthrough innovations, including the characteristics of collaborative network structures.
			Kupp, Marval, and Borchers (2017)	Business–business	Main success factors for collaboration: clear goals, a large external network, support from management, and performance indicators.	Not indicated
			Banerjee and Siebert (2017)	Business–business	In the bio-pharma industry, motivation for R&D cooperation increases with the severity of uncertainty. Early-stage collaborations primarily aim to reduce technological demand and profit uncertainty, while in later stages, funding becomes the dominant driver of R&D cooperation.	Exploring why late-stage R&D cooperation in drug development reduces the number of R&D projects, and examining the sources of different types of uncertainty in the pharmaceutical industry.

Type of crisis/ disruption	Number of occurrences	Hot topics/areas of collaboration studied in the papers	Authors of the top 3 most cited papers	Type of collaboration	Key findings	Future research directions indicated by the authors
Financial and economic crisis (including market disruptions)	**18**	**Product innovation, university-industry collaboration, information asymmetry**	Azagra-Caro et al. (2006)	Science–business	Industry–science collaboration differs from R&D cooperation, with the latter more strongly influenced by factors such as discipline, gender, and direct university support. Effective industry-science collaboration also depends on local absorptive capacity; in regions where this capacity is low, knowledge exchange has limited impact on development.	Studying the effects of the university's encouragement on R&D cooperation; developing theoretical foundations to explain the equilibrium between the degree of R&D and support for science-industry cooperation.
			Morandi (2013)	Science–business	Management practices and R&D cooperation impact the outcome of the projects. Task uncertainty causes the decentralization of coordination and control practices.	Focusing on different types of cooperative agreements and their implications for management practices.
			Abramo et al. (2011)	Science–business	Geographical proximity matters for partnerships between business and science. The market is inefficient in terms of selecting partners for public-private research collaboration. Bibliometrics can help to reduce the information asymmetry between the industry and science regarding collaboration.	Not indicated

Type of crisis/ disruption	Number of occurrences	Hot topics/areas of collaboration studied in the papers	Authors of the top 3 most cited papers	Type of collaboration	Key findings	Future research directions indicated by the authors
Institutional disruption/ uncertainty	**16**	**Collaborative working, alliances**	Vargo, Wieland, and Akaka (2015)	All actors in the service innovation ecosystem	Disruption and change of institutions guide interaction among actors in the ecosystem of service innovation. Collaboration and co-creation may provide novel solutions to existing problems.	Developing the effectuation theory of entrepreneurship.
			Sirmon and Lane (2004)	Business–business	When value is created by sharing, combining, and leveraging complementary resources, collaboration becomes more effective when the disruptive sources of cultural differences are eliminated.	Collaboration and cultural differences in inter-firm relationships that focus on cost-cutting or integrating similar resources.
			Gao and Zhong (2022)	Business–business	Collaboration efficiency is associated with a high-quality information environment and transparency. Informal relationships are more important than formal contracts for the improvement of collaborative outcomes.	Not indicated by the authors.

Type of crisis/ disruption	Number of occurrences	Hot topics/areas of collaboration studied in the papers	Authors of the top 3 most cited papers	Type of collaboration	Key findings	Future research directions indicated by the authors
Humanitarian crisis	**13**	**Refugees, health, ethics, humanitarian aid**	de Laat et al. (2021)	Science–business–government (all stakeholders)	Cultural differences, global inequalities, and ethical issues limit research collaboration on humanitarian conflicts. Managing cross-border research teams with various cultural backgrounds poses a challenge to collaboration.	Further studies on research relations are sensitive to vulnerabilities and characterized by unequal power among research partners.
			Dave et al. (2016)	Science–science Science–business	Key themes for collaboration identified: ethics of innovation, responsibilities of humanitarian practitioners and non-governmental organizations (NGOs), and vulnerability.	Collaborative research exploring the integration of new technologies in humanitarian actions and navigating humanitarian aid.
			Zakir Hossain (2022)	Science–science	The most intensive international research collaboration on the Rohingya refugee crisis involved researchers from Bangladesh collaborating with the UK, USA, Germany, Australia, and India.	Studying refugee-related issues in collaboration with scholars from refugee-hosting and asylum-seeking countries.

Source: authors' elaboration.

Across six types of crises and disruptions, R&D collaboration takes distinct forms shaped by the nature of the uncertainty involved. **Environmental disruptions** highlight the need for transdisciplinary and multi-stakeholder collaboration, demonstrating that broad engagement of stakeholders (e.g., in Nepal's water crisis) can reduce uncertainty and support sustainable management. Studies in this area emphasize sustainability, climate change, and security as major hotspots, while pointing to the importance of co-location and capacity-building within research teams. **Global health crises**, especially COVID-19, accelerated international scientific collaboration, though unevenly across countries and disciplines, with medicine emerging as the dominant field. Leading studies reveal persistent geographical asymmetries and call for further research on the interaction between scientific collaboration and geopolitical rivalry, as well as on mental health-related challenges.

In contexts of **technological disruption**, successful breakthrough innovation depends on firms' access to external knowledge and strong ties between actors of the triple helix: industry, academia, and government. Hotspots in this domain include digital transformation, open innovation, and Industry 4.0, particularly in the medical and pharmaceutical sectors. Collaboration motives shift as projects progress: early-stage cooperation reduces technological and market uncertainty, whereas funding drives later-stage partnerships. Future research is encouraged to examine network structures and uncertainty sources that influence innovation outcomes. **Financial and economic crises** emphasize university-industry collaboration, showing that absorptive capacity, geographical proximity, and information transparency shape successful partnerships. However, the relatively limited number of studies in this area indicates a research gap regarding collaboration under prolonged market instability. Under **institutional disruption**, collaboration is driven by shifts in institutional environments, with co-creation and complementary resource sharing helping actors respond to uncertainty, while cultural and informational factors determine effectiveness. Emerging research hotspots focus on alliances, informal governance mechanisms, and service innovation ecosystems, yet empirical evidence remains scarce.

Finally, **humanitarian crises** require collaboration across science, industry, and government, but cultural differences, ethical concerns, and global inequalities often constrain partnership effectiveness, particularly in refugee-related research. Although recent studies highlight the growing importance of interdisciplinary and cross-border cooperation in this field, research gaps persist regarding power asymmetries, vulnerability, and equitable knowledge production.

Despite growing scholarly attention to crisis-related R&D collaboration, important research gaps remain. Existing studies tend to focus on short-term responses, with limited longitudinal and comparative analyses across crisis types. Research is also geographically concentrated in high-income countries, while power asymmetries, governance challenges, and unequal resource access remain insufficiently examined. Moreover, the social and ethical consequences of collaboration are not yet systematically addressed. Addressing these gaps would support the development of more resilient, inclusive, and effective R&D collaboration frameworks.

Across crisis contexts, the reviewed studies reveal considerable variation in dominant collaboration types, reflecting differences in knowledge requirements, institutional settings, and stakeholder involvement. **Environmental and global health crises** are predominantly characterized

by science–science and transdisciplinary collaborations, often involving international research networks and interdisciplinary teams. In some cases, citizens are also included as partners in such collaborative research. **Technological disruptions** are more frequently associated with business involvement, business–science–government and business–business partnerships emerging as the most frequent, which highlighs the importance of innovation ecosystems and triple-helix arrangements for breakthrough development. **Financial and economic crises** often rely on science–business cooperation, with universities and firms jointly addressing market and organizational uncertainty. **Institutional disruptions** emphasize business–business and ecosystem-level collaboration, where informal relationships and complementary resources play a central role. In **humanitarian crises**, multi-actor collaboration involving academia, industry, government, and civil society is visible, reflecting the complex ethical, social, and operational challenges of humanitarian research. Overall, these patterns indicate that collaboration structures adapt to crisis-specific demands.

Overall, the findings show that while collaboration consistently increases during crises, its motivations, structures, and effectiveness vary sharply across crisis types, indicating significant opportunities for future research on governance, equity, and the management of uncertainty in crisis-driven R&D collaboration.

Discussion

This paper is driven by the need to examine the body of research on international collaborative R&D efforts initiated by researchers to address challenges arising during times of crisis or disruptive events. Our analysis shows that while interest in this field is growing, important structural and thematic imbalances remain, both in terms of who participates in collaborative research and what topics dominate the literature.

From a geographical perspective, our mapping of authorship and co-authorship networks reveals a clear dominance of high-income countries, with the United States, the United Kingdom, and China emerging as central hubs. The strongest bilateral ties between the USA and China, and between China and the UK, reflect long-standing strategic partnerships in global science. These patterns align with previous observations (Okamura 2023), though recent geopolitical tensions suggest these ties may be weakening. While our findings do not yet capture this decline, they point to the need for longitudinal studies that examine the evolving geopolitical dynamics of international R&D collaboration.

More broadly, the dominance of high-income countries in this field reflects deep-seated structural inequalities in the global research ecosystem. Access to funding, infrastructure, and international networks remains highly uneven, limiting the participation of scholars from low- and middle-income countries. This pattern reflects broader structural imbalances in the global research ecosystem, where funding availability, research infrastructure, and access to international networks are disproportionately concentrated in wealthier nations (Reuer and Devarakonda 2017; Chan et al. 2020; Yilmazkuday 2025). Language barriers, limited presence in high-impact journals, and divergent research priorities further contribute to this marginalization (Chan et al. 2020;

Yilmazkuday 2025). These challenges are particularly acute during crises, when rapid mobilization of resources and access to established networks can determine whose voices are heard and whose research is represented on the global stage.

Turning to the thematic scope of the literature, different types of crises shape collaboration dynamics in distinct ways. Environmental crises, particularly climate change, are among the most studied drivers of international R&D collaboration. Research results emphasize the need for stakeholder networking and participatory approaches that bridge disciplines, sectors, and regions (Orecchini, Valitutti, and Vitali 2012; Gaziulusoy et al. 2016; Pandey and Bajracharya 2017). Some studies also stress the need to enhance the management of R&D collaboration and point out the growing role of leadership (Gaziulusoy et al. 2016). Future research directions point to the development of new tools for managing collaboration and knowledge exchange in the face of ongoing environmental disruption (Orecchini et al. 2012; Pandey and Bajracharya 2017).

Health crises, such as the COVID-19 pandemic, have also intensified international R&D collaboration, especially in medical sciences. The urgency and scale of the pandemic prompted an unprecedented wave of cooperation, often led by academic institutions and facilitated by global digital networks. At the same time, scholars have begun to question how such collaboration intersects with issues of geopolitical rivalry and long-term scientific independence (Kim and Cho 2021; Lee and Haupt 2021b; Nguyen et al. 2021). These considerations underscore the need to examine not only the mechanics but also the politics of international collaboration in times of crisis.

Technological disruptions, including digital transformation and biotech innovation, are another important driver of R&D collaboration. Technology shocks generate uncertainty while simultaneously creating windows for innovation. Firms, particularly in sectors like biopharma, are incentivized to enter R&D partnerships that offer access to complementary capabilities and market expansion opportunities (Grimes and Miozzo 2015). Successful collaboration in these contexts depends not only on strategic alignment but also on robust management structures, open innovation strategies, and trust-based social capital (Baba and Walsh 2010).

Financial and economic crises (including the Great Recession of 2008) have historically motivated science–business collaboration, with studies highlighting factors such as geographical proximity, local absorptive capacity, and managerial coordination as key to success (Azagra-Caro et al. 2006) and how it has been managed (Morandi 2013). The key conclusions from this strand of research highlight factors that matter for successful science-business collaboration, such as the geographical proximity of partners (Abramo et al. 2011), local absorptive capacity (Azagra-Caro et al. 2006), or well-designed management practices (Morandi 2013). Emerging research topics identified in the literature concern the role of support for science-industry cooperation and types of partnership agreements between business and science.

Institutional uncertainty, including regulatory change, weak governance, and cultural divergence, also plays a complex role in shaping R&D collaboration. Studies emphasize the need to balance formal and informal relationships and to navigate differences in information environments (Gao and Zhong 2022). Future research could build on effectuation theory to better

understand how actors adapt to ambiguous or shifting institutional contexts (Vargo, Wieland, and Akaka 2015).

A growing, yet still underexplored area is humanitarian crises, which call for intensified interdisciplinary R&D collaboration, particularly in addressing health and ethical challenges related to refugees and displaced populations (Dave et al. 2016; de Laat et al. 2021; Zakir Hossain 2022). These contexts introduce unique management challenges tied to cultural differences, inequality, and vulnerability. Scholars have called for research approaches that are sensitive to power imbalances and that promote equity in collaborative relationships (de Laat et al. 2021). This area offers ground for studies that explore inclusive, participatory, and ethically grounded models of collaboration.

Finally, a cross-cutting observation is that most of the existing literature continues to focus on bilateral R&D collaborations: science–science, business–business, or science–business. Very few studies adopt a systemic perspective that includes all relevant innovation actors, such as citizens and civil society organizations, in co-creative or participatory research models. However, it has been observed that although collaborations can foster equity and societal change, asymmetries between actors risk distorting knowledge and reinforcing inequalities, creating persistent challenges for international development research (Bender 2022), and thus, for realizing the ambitions of open science and responsible innovation frameworks.

The observed collaboration patterns can be further interpreted through the lenses of open innovation and resource dependence theory. From an open innovation perspective, international R&D networks reflect strategic efforts to access external knowledge and manage uncertainty. Resource dependence theory, in turn, highlights that collaborative network structures and asymmetries may be related to differences in access to funding, infrastructure, and expertise. Together, these perspectives provide a framework for understanding why certain countries tend to occupy more central positions, while others remain more peripheral. Our approach focuses on bibliometric analysis of macro-level structures; however, the literature indicates that organizational and individual-level factors, such as leadership, trust, and knowledge governance, also influence collaborative behavior. This highlights a promising avenue for further investigation through complementary research approaches using micro-level data on organizations involved in collaborative R&D projects.

To wrap up, crises, whether environmental, technological, economic, institutional, or humanitarian, act as both disruptors and enablers of international R&D collaboration. They expose weaknesses in current systems while also revealing new pathways for collaboration. Furthremore, the literature review of existing studies on R&D collaboration related to disruptions and crises also reveals that ethical, cultural, and geopolitical dimensions remain a critical challenge in shaping crisis-driven collaboration.

Conclusions, implications, and future research directions

This paper examined international research collaboration in the field of social sciences that focused on responses to global crises and disruptions, with particular attention to how such collaborations are structured and interpreted across diverse thematic contexts. Using a bibliometric

review, complemented by a systematic literature assessment, we addressed the central research questions: **How has existing research explored R&D collaborations focused on finding solutions to disruptive events or crises? What key themes have emerged, and what research gaps remain in the current literature?**

Our findings show that collaboration on various topics related to crises and disruptions remains highly concentrated in the United States, the United Kingdom, and Germany, with notable bilateral ties to China. Yet, overall collaboration density in the global collaboration network is modest, highlighting underdeveloped transnational knowledge exchange despite the global nature of crises. Six thematic clusters dominate the literature: environmental crises, health emergencies, technological disruption, economic shocks, institutional instability, and humanitarian challenges. Together, they reveal how uncertainty reshapes innovation but also creates opportunities for adaptive responses.

At the same time, the bibliometric analysis and the review of the existing studies highlight their major limitations. Researchers from the Global South and from Central and Eastern Europe remain significantly underrepresented in R&D networks, reflecting structural inequalities in resources, access, and visibility. Furthermore, most studies on research collaboration related to disruptive events examine bilateral partnerships (e.g., business–business, science–business), while approaches involving policymakers, citizens, and non-traditional actors are seldom addressed. These asymmetries may limit the participation of some stakeholders in R&D research networks and, to some extent, also influence global research agendas and outcomes.

This study contributes to the existing body of knowledge by mapping prevailing patterns of R&D collaboration related to crises or disruptions, identifying critical knowledge gaps, and offering evidence to potentially guide researchers, practitioners, and policymakers in designing more inclusive, collaborative, resilient, and globally integrated R&D systems.

From a comparative economic perspective, these patterns underscore persistent imbalances in global knowledge production and diffusion, mirroring broader disparities in economic development, institutional capacity, and innovation systems. Such asymmetries affect not only research collaboration but also the ability to respond collectively to shocks and systemic disruptions.

Based on the observed collaboration patterns, these findings suggest tentative implications for comparative and policy-oriented research. The identified research gaps related to geographical asymmetries in collaboration networks and the dominance of bilateral links indicate the importance of further research on inclusive collaboration frameworks that bring together actors from different countries and across stakeholder groups, such as industry, academia, and government. The review of existing studies on R&D collaboration in the context of disruptions and crises suggests that ethical, cultural, and geopolitical dimensions continue to pose significant challenges in R&D collaboration and represent promising topics for future comparative research. Furthermore, recognizing that causal mechanisms cannot be inferred from bibliometric data alone, closer examination of R&D collaboration related to disruptive events using complementary quantitative and mixed-method approaches represents an important direction for further studies.

This study has several limitations related to its time frame and methodological approach. We ended our empirical analysis in 2023 to ensure data completeness and reliability, as more recent bibliometric records are often affected by indexing delays and revisions. As a result, the most recent developments may not be fully captured. In addition, the study relies on bibliometric analysis of journal articles, which may overlook other forms of scholarly output and collaborative activities. The selection criteria and database coverage, while carefully defined, also reflect our methodological choices that may influence the scope and representativeness of the reviewed literature. Consequently, the findings should be interpreted with these limitations in mind, and future research may benefit from using updated data and complementary quantitative, qualitative, or mixed-method approaches.

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References

Abramo, G., D'Angelo, C.A., Di Costa, F. (2022), *How the Covid-19 crisis shaped research collaboration behaviour*, "Scientometrics", 127 (8), pp. 5053–5071, https://doi.org/10.1007/s11192-022-04450-2

Abramo, G., D'Angelo, C.A., Di Costa, F., Solazzi, M. (2011), *The role of information asymmetry in the market for university–industry research collaboration*, "The Journal of Technology Transfer", 36 (1), pp. 84–100, https://doi.org/10.1007/s10961-009-9131-5

Amoroso, S., Coad, A., Grassano, N. (2018), *European R&D networks: a snapshot from the 7th EU Framework Programme*, "Economics of Innovation and New Technology", 27 (5–6), pp. 404–419, https://doi.org/10.1080/10438599.2017.1374037

Anderson, M.S., Steneck, N.H. (eds.) (2010), *International Research Collaborations. Much to be Gained, Many Ways to Get in Trouble*, Routledge, New York, https://doi.org/10.4324/9780203848906

Azagra-Caro, J.M., Archontakis, F., Gutiérrez-Gracia, A., Fernández-de-Lucio, I. (2006), *Faculty support for the objectives of university–industry relations versus degree of R&D cooperation: The importance of regional absorptive capacity*, "Research Policy", 35 (1), pp. 37–55, https://doi.org/10.1016/j.respol.2005.08.007

Baba, Y., Walsh, J.P. (2010), *Embeddedness, social epistemology and breakthrough innovation: The case of the development of statins*, "Research Policy", 39 (4), pp. 511–522, https://doi.org/10.1016/j.respol.2010.01.016

Ballesteros-Ballesteros, V.A., Zárate-Torres, R.A. (2025), *Mapping the conceptual structure of research on open innovation in university–industry collaborations: A bibliometric analysis*, "Frontiers in Research Metrics and Analytics", 10, 1693969, https://doi.org/10.3389/frma.2025.1693969

Bamberger, A., Huang, T.-Y. (2025), *From irreversible openness to protectionism: geopolitics and international research cooperation in the European Union*, "Journal of Education Policy", 40 (1), pp. 19–43, https://doi.org/10.1080/02680939.2024.2351516

Banerjee, T., Siebert, R. (2017), *Dynamic impact of uncertainty on R&D cooperation formation and research performance: Evidence from the bio-pharmaceutical industry*, "Research Policy", 46 (7), pp. 1255–1271, https://doi.org/10.1016/j.respol.2017.05.009

Becken, S. (2013), *A review of tourism and climate change as an evolving knowledge domain*, "Tourism Management Perspectives", 6, pp. 53–62, https://doi.org/10.1016/j.tmp.2012.11.006

Belderbos, R., Lokshin, B., Boone, C., Jacob, J. (2022), *Top management team international diversity and the performance of international R&D*, "Global Strategy Journal", 12 (1), pp. 108–133, https://doi.org/10.1002/gsj.1395

Belderbos, R., Park, J., Carree, M. (2021), *Do R&D investments in weak IPR countries destroy market value? The role of internal linkages*, "Strategic Management Journal", 42 (8), pp. 1401–1431, https://doi.org/10.1002/smj.3268

Belderbos, R., Van Roy, V., Leten, B., Thijs, B. (2014), *Academic Research Strengths and Multinational Firms' Foreign R&D Location Decisions: Evidence from R&D Investments in European Regions*, "Environment and Planning A: Economy and Space", 46 (4), pp. 920–942, https://doi.org/10.1068/a45536

Belli, S., Mugnaini, R., Baltà, J., Abadal, E. (2020), *Coronavirus mapping in scientific publications: When science advances rapidly and collectively, is access to this knowledge open to society?*, "Scientometrics", 124 (3), pp. 2661–2685, https://doi.org/10.1007/s11192-020-03590-7

Bender, K. (2022), *Research–Practice–Collaborations in International Sustainable Development and Knowledge Production: Reflections from a Political-Economic Perspective*, "The European Journal of Development Research", 34 (4), pp. 1691–1703, https://doi.org/10.1057/s41287-022-00549-7

Bengoa, A., Maseda, A., Iturralde, T., Aparicio, G. (2021), *A bibliometric review of the technology transfer literature*, "The Journal of Technology Transfer", 46 (5), pp. 1514–1550, https://doi.org/10.1007/s10961-019-09774-5

Bhandal, R., Meriton, R., Kavanagh, R.E., Brown, A. (2022), *The application of digital twin technology in operations and supply chain management: a bibliometric review*, "Supply Chain Management: An International Journal", 27 (2), pp. 182–206, https://doi.org/10.1108/SCM-01-2021-0053

Bozeman, B., Boardman, C. (2014), *Research Collaboration and Team Science: A State-of-the-Art Review and Agenda*, Springer International Publishing, Cham–Heidelberg–New York–Dordrecht–London, https://doi.org/10.1007/978-3-319-06468-0

Cai, X., Fry, C.V., Wagner, C.S. (2021), *International collaboration during the COVID-19 crisis: autumn 2020 developments*, "Scientometrics", 126 (4), pp. 3683–3692, https://doi.org/10.1007/s11192-021-03873-7

Castelló-Sirvent, F., Roger-Monzó, V. (2022), *Research agenda on turnaround strategies beyond systemic disruptions*, "Journal of Organizational Change Management", 36 (1), pp. 86–105, https://doi.org/10.1108/JOCM-05-2022-0160

Cerver Romero, E., Ferreira, J.J.M., Fernandes, C.I. (2021), *The multiple faces of the entrepreneurial university: a review of the prevailing theoretical approaches*, "The Journal of Technology Transfer", 46 (4), pp. 1173–1195, https://doi.org/10.1007/s10961-020-09815-4

Chan, L., Hall, B., Piron, F., Tandon, R., Williams, W.L. (2020), *Open Science Beyond Open Access: For and with communities, A step towards the decolonization of knowledge*, https://doi.org/10.5281/ZENODO.3946772

Chen, K., Zhang, Y., Fu, X. (2019), *International research collaboration: An emerging domain of innovation studies?*, "Research Policy", 48 (1), pp. 149–168, https://doi.org/10.1016/j.respol.2018.08.005

Chesbrough, H.W. (2003), *Open Innovation: The new imperative for creating and profiting from technology*, Harvard Business School Press, Boston.

Chesbrough, H.W. (2024), *Open Innovation: Accomplishments and Prospects for the Next 20 Years*, "California Management Review", 67 (1), pp. 164–180, https://doi.org/10.1177/00081256241273964

Corrêa, V.S., Lima, R.M.D., Brito, F.R.D.S., Machado, M.C., Nassif, V.M.J. (2022), *Female entrepreneurship in emerging and developing countries: a systematic review of practical and policy implications and suggestions for new studies*, "Journal of Entrepreneurship in Emerging Economies", 16 (2), pp. 366–395, https://doi.org/10.1108/JEEE-04-2022-0115

Daim, T.U., Yalçın, H. (2022), *Digital Transformations: New Tools and Methods for Mining Technological Intelligence*, Edward Elgar Publishing, Cheltenham–Northampton, https://doi.org/10.4337/9781789908633

Damaševičius, R., Zailskaitė-Jakštė, L. (2022), *Impact of COVID-19 pandemic on researcher collaboration in business and economics areas on national level: a scientometric analysis*, "Journal of Documentation", 79 (1), pp. 183–202, https://doi.org/10.1108/JD-02-2022-0030

Damaševičius, R., Zailskaitė-Jakštė, L. (2023), *The Impact of a National Crisis on Research Collaborations: A Scientometric Analysis of Ukrainian Authors 2019–2022*, "Publications", 11 (3), 42, https://doi.org/10.3390/publications11030042

Dave, A., Cumin, J., Chung, R., Hunt, M. (2016), *Engaging Ethical Issues Associated with Research and Public Health Interventions During Humanitarian Crises: Review of a Dialogic Workshop*, "BioéthiqueOnline", 5, https://doi.org/10.7202/1044260ar

De Stefano, D., Fuccella, V., Vitale, M.P., Zaccarin, S. (2023), *Quality issues in co-authorship data of a national scientific community*, "Network Science", 11 (1), pp. 98–112, https://doi.org/10.1017/nws.2022.40

Drees, J.M., Heugens, P.P.M.A.R. (2013), *Synthesizing and Extending Resource Dependence Theory: A Meta-Analysis*, "Journal of Management", 39 (6), pp. 1666–1698, https://doi.org/10.1177/0149206312471391

Du, J., Leten, B., Vanhaverbeke, W. (2014), *Managing open innovation projects with science-based and market-based partners*, "Research Policy", 43 (5), pp. 828–840, https://doi.org/10.1016/j.respol.2013.12.008

European Commission (2025), *ERA scoreboard 2024*, Directorate-General for Research and Innovation, Publications Office of the European Union, https://data.europa.eu/doi/10.2777/9564855

European Parliamentary Research Service (2018), *Overcoming innovation gaps in the EU-13 Member States*, European Parliamentary Research Service Scientific Foresight Unit (STOA), https://www.europarl.europa.eu/RegData/etudes/STUD/2018/614537/EPRS_STU(2018)614537_EN.pdf (accessed: 4.02.2026).

Fernandes, A.J., Ferreira, J.J. (2022), *Entrepreneurial ecosystems and networks: a literature review and research agenda*, "Review of Managerial Science", 16 (1), pp. 189–247, https://doi.org/10.1007/s11846-020-00437-6

Fu, X., Fu, X., Romero, C.C., Pan, J. (2021), *Exploring new opportunities through collaboration within and beyond sectoral systems of innovation in the fourth industrial revolution*, "Industrial and Corporate Change", 30 (1), pp. 233–249, https://doi.org/10.1093/icc/dtaa058

Fu, X., Li, J. (2016), *Collaboration with foreign universities for innovation: evidence from Chinese manufacturing firms*, "International Journal of Technology Management", 70 (2/3), pp. 193–217, https://doi.org/10.1504/IJTM.2016.075162

Gao, F., Zhong, R. (2022), *Information environment and interfirm alliance*, "Review of Quantitative Finance and Accounting", 60 (2), pp. 643–677, https://doi.org/10.1007/s11156-022-01105-4

Gao, J., Nyhan, J., Duke-Williams, O., Mahony, S. (2022), *Gender influences in Digital Humanities co-authorship networks*, "Journal of Documentation", 78 (7), pp. 327–350, https://doi.org/10.1108/JD-11-2021-0221

Gao, J., Nyhan, J., Duke-Williams, O., Mahony, S. (2023), *Exploring international collaboration and language dynamics in Digital Humanities: insights from co-authorship networks in canonical journals*, "Journal of Documentation", 79 (7), pp. 240–260, https://doi.org/10.1108/JD-06-2023-0113

Gao, Y., Lin, R., Lu, Y. (2022), *A Visualized Analysis of the Research Current Hotspots and Trends on Innovation Chain Based on the Knowledge Map*, "Sustainability", 14 (3), 1708, https://doi.org/10.3390/su14031708

Garfield, E. (1955), *Citation Indexes for Science: A New Dimension in Documentation through Association of Ideas*, "Science", 122 (3159), pp. 108–111, https://doi.org/10.1126/science.122.3159.108

Gaziulusoy, A.I., Ryan, C., McGrail, S., Chandler, P., Twomey, P. (2016), *Identifying and addressing challenges faced by transdisciplinary research teams in climate change research*, "Journal of Cleaner Production", 123, pp. 55–64, https://doi.org/10.1016/j.jclepro.2015.08.049

Glänzel, W., Schubert, A. (2005), *Analysing scientific networks through co-authorship*, [in:] H.F. Moed, W. Glänzel, U. Schmoch (eds.), *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems*, Springer Science + Business Media, Inc., Dordrecht, pp. 257–276, https://doi.org/10.1007/1-4020-2755-9

Gray, B., Purdy, J., Ansari, S. (2022), *Confronting Power Asymmetries in Partnerships to Address Grand Challenges*, "Organization Theory", 3 (2), https://doi.org/10.1177/26317877221098765

Gretsch, O., Salzmann, E.C., Kock, A. (2019), *University-industry collaboration and front-end success: the moderating effects of innovativeness and parallel cross-firm collaboration*, "R&D Management", 49 (5), pp. 835–849, https://doi.org/10.1111/radm.12385

Grimes, S., Miozzo, M. (2015), *Big Pharma's Internationalization of R&D to China*, "European Planning Studies", 23 (9), pp. 1873–1894, https://doi.org/10.1080/09654313.2015.1029442

Guimón, J., Narula, R. (2020), *Ending the COVID-19 Pandemic Requires More International Collaboration*, "Research-Technology Management", 63 (5), pp. 38–41, https://doi.org/10.1080/08956308.2020.1790239

Healy, M., Hammer, S., McIlveen, P. (2022), *Mapping graduate employability and career development in higher education research: a citation network analysis*, "Studies in Higher Education", 47 (4), pp. 799–811, https://doi.org/10.1080/03075079.2020.1804851

Hurtado-Torres, N.E., Aragón-Correa, J.A., Ortiz-de-Mandojana, N. (2018), *How does R&D internationalization in multinational firms affect their innovative performance? The moderating role of international collaboration in the energy industry*, "International Business Review", 27 (3), pp. 514–527, https://doi.org/10.1016/j.ibusrev.2017.10.003

Janssen, M.A., Schoon, M.L., Ke, W., Börner, K. (2006), *Scholarly networks on resilience, vulnerability and adaptation within the human dimensions of global environmental change*, "Global Environmental Change", 16 (3), pp. 240–252, https://doi.org/10.1016/j.gloenvcha.2006.04.001

Kameda, K., Kelly, A.H., Lezaun, J., Löwy, I. (2021), *Imperfect diagnosis: The truncated legacies of Zika testing*, "Social Studies of Science", 51 (5), pp. 683–706, https://doi.org/10.1177/03063127211035492

Kapucu, N., Arslan, T., Collins, M.L. (2010), *Examining Intergovernmental and Interorganizational Response to Catastrophic Disasters: Toward a Network-Centered Approach*, "Administration & Society", 42 (2), pp. 222–247, https://doi.org/10.1177/0095399710362517

Kessler, M.M. (1963), *Bibliographic coupling between scientific papers*, "American Documentation", 14 (1), pp. 10–25, https://doi.org/10.1002/asi.5090140103

Kiani Mavi, R., Gengatharen, D., Kiani Mavi, N., Hughes, R., Campbell, A., Yates, R. (2021), *Sustainability in Construction Projects: A Systematic Literature Review*, "Sustainability", 13 (4), 1932, https://doi.org/10.3390/su13041932

Kim, K., Cho, K.T. (2021), *A Review of Global Collaboration on COVID-19 Research during the Pandemic in 2020*, "Sustainability", 13 (14), 7618, https://doi.org/10.3390/su13147618

Kozmenko, S., Vorontsova, A., Ostapenko, L., Plastun, A., Plastun, V. (2025), *Sanctions on Russian academia: Are they efficient?*, "Journal of International Studies", 18 (2), pp. 255–269, https://doi.org/10.14254/2071-8330.2025/18-2/14

Kraus, S., Breier, M., Lim, W.M., Dabić, M., Kumar, S., Kanbach, D., Mukherjee, D., Corvello, V., Piñeiro-Chousa, J., Liguori, E., Palacios-Marqués, D., Schiavone, F., Ferraris, A., Fernandes, C., Ferreira, J.J. (2022), *Literature reviews as independent studies: guidelines for academic practice*, "Review of Managerial Science", 16 (8), pp. 2577–2595, https://doi.org/10.1007/s11846-022-00588-8

Kryszak, Ł., Świerczyńska, K., Staniszewski, J. (2023), *Measuring total factor productivity in agriculture: a bibliometric review*, "International Journal of Emerging Markets", 18 (1), pp. 148–172, https://doi.org/10.1108/IJOEM-04-2020-0428

Kupp, M., Marval, M., Borchers, P. (2017), *Corporate accelerators: fostering innovation while bringing together startups and large firms*, "Journal of Business Strategy", 38 (6), pp. 47–53, https://doi.org/10.1108/JBS-12-2016-0145

Laat, S. de, Wahoush, O., Jaber, R., Khater, W., Musoni, E., Abu Siam, I., Schwartz, L. (2021), *A case analysis of partnered research on palliative care for refugees in Jordan and Rwanda*, "Conflict and Health", 15 (1), pp. 1–8, https://doi.org/10.1186/s13031-020-00333-6

Lattu, A., Cai, Y. (2023), *Institutional logics in the open science practices of university–industry research collaboration*, "Science and Public Policy", 50 (5), pp. 905–916, https://doi.org/10.1093/scipol/scad037

Lee, J.J., Haupt, J.P. (2021a), *Scientific Collaboration on COVID-19 Amidst Geopolitical Tensions between the US and China*, "The Journal of Higher Education", 92 (2), pp. 303–329, https://doi.org/10.1080/00221546.2020.1827924

Lee, J.J., Haupt, J.P. (2021b), *Scientific globalism during a global crisis: research collaboration and open access publications on COVID-19*, "Higher Education", 81 (5), pp. 949–966, https://doi.org/10.1007/s10734-020-00589-0

Lee, P.-C., Su, H.-N. (2010), *Investigating the structure of regional innovation system research through keyword co-occurrence and social network analysis*, "Innovation", 12 (1), pp. 26–40, https://doi.org/10.5172/impp.12.1.26

Li, H., An, H., Wang, Y., Huang, J., Gao, X. (2016), *Evolutionary features of academic articles co-keyword network and keywords co-occurrence network: Based on two-mode affiliation network*, "Physica A: Statistical Mechanics and Its Applications", 450, pp. 657–669, https://doi.org/10.1016/j.physa.2016.01.017

Li, Y., Rong, Y., Ahmad, U.M., Wang, X., Zuo, J., Mao, G. (2021), *A comprehensive review on green buildings research: bibliometric analysis during 1998–2018*, "Environmental Science and Pollution Research", 28 (34), pp. 46196–46214, https://doi.org/10.1007/s11356-021-12739-7

Macaulay, C.D.T. (2025), *Power asymmetries in inter-organizational relationships: a case study using institutionalism*, "Sport, Business and Management: An International Journal", 15 (2), pp. 140–160, https://doi.org/10.1108/SBM-07-2024-0092

Makkonen, T., Mitze, T. (2023), *Geopolitical conflicts, sanctions and international knowledge flows: EU–Russia collaboration during the Ukraine crisis*, "The World Economy", 46 (10), pp. 2926–2949, https://doi.org/10.1111/twec.13421

Mokhtari, H., Barkhan, S., Haseli, D., Saberi, M.K. (2020), *A bibliometric analysis and visualization of the Journal of Documentation: 1945–2018*, "Journal of Documentation", 77 (1), pp. 69–92, https://doi.org/10.1108/JD-08-2019-0165

Moody, J. (2004), *The Structure of a Social Science Collaboration Network: Disciplinary Cohesion from 1963 to 1999*, "American Sociological Review", 69 (2), pp. 213–238, https://doi.org/10.1177/000312240406900204

Morandi, V. (2013), *The management of industry–university joint research projects: how do partners coordinate and control R&D activities?*, "The Journal of Technology Transfer", 38 (2), pp. 69–92, https://doi.org/10.1007/s10961-011-9228-5

Nazzal, A., Sánchez-Rebull, M.-V., Niñerola, A. (2023), *Foreign direct investment by multinational corporations in emerging economies: a comprehensive bibliometric analysis*, "International Journal of Emerging Markets", 20 (13), pp. 244–269, https://doi.org/10.1108/IJOEM-12-2021-1878

Newman, M.E.J. (2001), *The structure of scientific collaboration networks*, "Proceedings of the National Academy of Sciences", 98 (2), pp. 404–409, https://doi.org/10.1073/pnas.98.2.404

Nguyen, A., Brown, B., El Tantawi, M., Ndembi, N., Okeibunor, J., Mohammed, A., Folayan, M.O. (2021), *Time to Scale-up Research Collaborations to Address the Global Impact of COVID-19 – A Commentary*, "Health Behavior and Policy Review", 8 (3), pp. 277–280, https://doi.org/10.14485/HBPR.8.3.9

O'Dwyer, M., Filieri, R., O'Malley, L. (2022), *Establishing successful university–industry collaborations: barriers and enablers deconstructed*, "The Journal of Technology Transfer", 48, pp. 900–931, https://doi.org/10.1007/s10961-022-09932-2

OECD (2021), *OECD Science, Technology and Innovation Outlook 2021. Times of Crisis and Opportunity*, https://doi.org/10.1787/75f79015-en

Okamura, K. (2023), *A half-century of global collaboration in science and the "Shrinking World"*, "Quantitative Science Studies", 4 (4), pp. 938–959, https://doi.org/10.1162/qss_a_00268

Oliveira, A., Carvalho, F., Reis, N.R. (2022), *Institutions and Firms' Performance: A Bibliometric Analysis and Future Research Avenues*, "Publications", 10 (1), 8, https://doi.org/10.3390/publications10010008

Orecchini, F., Valitutti, V., Vitali, G. (2012), *Industry and academia for a transition towards sustainability: advancing sustainability science through university–business collaborations*, "Sustainability Science", 7, pp. 57–73, https://doi.org/10.1007/s11625-011-0151-3

Pandey, C.L., Bajracharya, R.M. (2017), *Climate Adaptive Water Management Practices in Small and Mid-sized Cities of Nepal: Case Studies of Dharan and Dhulikhel*, "Sustainability: The Journal of Record", 10 (5), pp. 300–307, https://doi.org/10.1089/sus.2017.0008

Pao, M.L. (1992), *Global and local collaborators: A study of scientific collaboration*, "Information Processing & Management", 28 (1), pp. 99–109, https://doi.org/10.1016/0306-4573(92)90096-I

Patel, N. (1973), *Collaboration in the Professional Growth of American Sociology*, "Social Science Information", 12 (6), pp. 77–92, https://doi.org/10.1177/053901847301200604

Pennetta, S., Anglani, F., Mathews, S. (2023), *Navigating through entrepreneurial skills, competencies and capabilities: a systematic literature review and the development of the entrepreneurial ability model*, "Journal of Entrepreneurship in Emerging Economies", 16 (4), pp. 1144–1182, https://doi.org/10.1108/JEEE-09-2022-0257

Pfeffer, J., Salancik, G.R. (1978), *The external control of organizations: A resource dependence perspective*, Harper and Row, New York.

Philbin, S. (2008), *Measuring the performance of research collaborations*, "Measuring Business Excellence", 12 (3), pp. 16–23, https://doi.org/10.1108/13683040810900368

Rani, T., Wang, F., Ur Rehman, S.A., Amjad, M.A. (2025), *Shaping sustainable futures in BRICS-T economies: The role of digitalization with moderating effects of green technology innovation and financial inclusion*, "Technology in Society", 82, 102879, https://doi.org/10.1016/j.techsoc.2025.102879

Reuer, J.J., Devarakonda, R. (2017), *Partner Selection in R&D Collaborations: Effects of Affiliations with Venture Capitalists*, "Organization Science", 28 (3), pp. 574–595, https://doi.org/10.1287/orsc.2017.1124

Rocha, C., Quandt, C., Deschamps, F., Philbin, S., Cruzara, G. (2022), *Collaborations for Digital Transformation: Case Studies of Industry 4.0 in Brazil*, "IEEE Transactions on Engineering Management", 70 (7), pp. 1–15, https://doi.org/10.1109/TEM.2021.3061396

Ruangpermpool, S., Igel, B., Siengthai, S. (2020), *Trust and dynamic governance mechanisms in the university-industry R&D alliances*, "Journal of Science and Technology Policy Management", 11 (2), 171–192, https://doi.org/10.1108/JSTPM-02-2019-0018

Sahil, N., Sood, S.K. (2021), *Scientometric Analysis of Natural Disaster Management Research*, "Natural Hazards Review", 22 (2), https://doi.org/10.1061/(ASCE)NH.1527-6996.0000447

Sampaio, R.B., Abreu Batista, A. de, Ferreira, B.S., Barreto, M.L., Mena-Chalco, J.P. (2020), *Scientometric Analysis of Research Output from Brazil In response to the Zika Crisis Using e-Lattes*, "Journal of Data and Information Science", 5 (4), pp. 137–146, https://doi.org/10.2478/jdis-2020-0038

Sardana, V., Singhania, S. (2022), *Fifty Years of Research in Deposit Insurance: A Bibliometric Analysis and Review*, "FIIB Business Review", 231971452211164, https://doi.org/10.1177/23197145221116455

Shih, T., Chubb, A., Cooney-O'Donoghue, D. (2024), *Scientific collaboration amid geopolitical tensions: a comparison of Sweden and Australia*, "Higher Education", 87 (5), pp. 1339–1356, https://doi.org/10.1007/s10734-023-01066-0

Sirmon, D.G., Lane, P.J. (2004), *A model of cultural differences and international alliance performance*, "Journal of International Business Studies", 35 (4), pp. 306–319, https://doi.org/10.1057/palgrave.jibs.8400089

Solla Price, D.J. de (1965), *Networks of Scientific Papers: The pattern of bibliographic references indicates the nature of the scientific research front*, "Science", 149 (3683), pp. 510–515, https://doi.org/10.1126/science.149.3683.510

Suzuki, S., Belderbos, R., Kwon, H.U. (2017), *The Location of Multinational Firms' R&D Activities Abroad: Host Country University Research, University–Industry Collaboration, and R&D Heterogeneity*, [in:] J. Alcácer, B. Kogut, C. Thomas, B.Y. Yeung (eds.), *Advances in Strategic Management. Geography, Location, and Strategy*, Vol. 36, Emerald Publishing Limited, Bingley, pp. 125–159, https://doi.org/10.1108/S0742-332220170000036005

Tian, Z., Gurnani, H., Xu, Y. (2021), *Collaboration in Development of New Drugs*, "Production and Operations Management", 30 (11), pp. 3943–3966, https://doi.org/10.1111/poms.13377

Tomeczek, A.F. (2022), *The evolution of Japanese keiretsu networks: A review and text network analysis of their perceptions in economics*, "Japan and the World Economy", 62, 101132, https://doi.org/10.1016/j.japwor.2022.101132

Tomeczek, A.F. (2025), *Innovative activities of Activision Blizzard: A patent network analysis*, "Entertainment Computing", 55, 101037, https://doi.org/10.1016/j.entcom.2025.101037

Tsouchnika, M., Smolyak, A., Argyrakis, P., Havlin, S. (2022), *Patent collaborations: From segregation to globalization*, "Journal of Informetrics", 16 (1), 101238, https://doi.org/10.1016/j.joi.2021.101238

Vargo, S.L., Wieland, H., Akaka, M.A. (2015), *Innovation through institutionalization: A service ecosystems perspective*, "Industrial Marketing Management", 44, pp. 63–72, https://doi.org/10.1016/j.indmarman.2014.10.008

Vong, C., Rita, P., António, N. (2021), *Health-Related Crises in Tourism Destination Management: A Systematic Review*, "Sustainability", 13 (24), 13738, https://doi.org/10.3390/su132413738

Wagner, C.S., Cai, X. (2022), *Changes in Co-Publication Patterns among China, the European Union (28) and the United States of America, 2016–2021*, "SSRN Electronic Journal", https://doi.org/10.2139/ssrn.4035897

Wagner, C.S., Park, H.W., Leydesdorff, L. (2015), *The Continuing Growth of Global Cooperation Networks in Research: A Conundrum for National Governments*, "PLOS ONE", 10 (7), e0131816, https://doi.org/10.1371/journal.pone.0131816

Wagner, C.S., Whetsell, T.A., Mukherjee, S. (2019), *International research collaboration: Novelty, conventionality, and atypicality in knowledge recombination*, "Research Policy", 48 (5), pp. 1260–1270, https://doi.org/10.1016/j.respol.2019.01.002

Wang, D., Huangfu, Y., Dong, Z., Dong, Y. (2022), *Research Hotspots and Evolution Trends of Carbon Neutrality – Visual Analysis of Bibliometrics Based on CiteSpace*, "Sustainability", 14 (3), 1078, https://doi.org/10.3390/su14031078

Weber, E.P., Khademian, A.M. (2008), *Wicked Problems, Knowledge Challenges, and Collaborative Capacity Builders in Network Settings*, "Public Administration Review", 68 (2), pp. 334–349, https://doi.org/10.1111/j.1540-6210.2007.00866.x

Wood, D.J., Mitchell, R.K., Agle, B.R., Bryan, L.M. (2021), *Stakeholder Identification and Salience After 20 Years: Progress, Problems, and Prospects*, "Business & Society", 60 (1), pp. 196–245, https://doi.org/10.1177/0007650318816522

Wu, L., Yang, J., Wang, D., Cheng, Q., Lu, W. (2021), *Scientists' response to global public health emergencies: A bibliometrics perspective*, "Journal of Information Science", 49 (4), https://doi.org/10.1177/01655515211030866

Xu, X., Hou, G., Wang, J. (2022), *Research on Digital Transformation Based on Complex Systems: Visualization of Knowledge Maps and Construction of a Theoretical Framework*, "Sustainability", 14 (5), 2683, https://doi.org/10.3390/su14052683

Yadav, N., Kumar, R., Malik, A. (2022), *Global developments in coopetition research: A bibliometric analysis of research articles published between 2010 and 2020*, "Journal of Business Research", 145, pp. 495–508, https://doi.org/10.1016/j.jbusres.2022.03.005

Yalcin, H., Daim, T. (2021), *A scientometric review of technology capability research*, "Journal of Engineering and Technology Management", 62, 101658, https://doi.org/10.1016/j.jengtecman.2021.101658

Yao, B. (2021), *International Research Collaboration: Challenges and Opportunities*, "Journal of Diagnostic Medical Sonography", 37 (2), pp. 107–108, https://doi.org/10.1177/8756479320976130

Ye, Y., De Moortel, K., Crispeels, T. (2020), *Network dynamics of Chinese university knowledge transfer*, "The Journal of Technology Transfer", 45 (4), pp. 1228–1254, https://doi.org/10.1007/s10961-019-09748-7

Yilmazkuday, H. (2025), *Geopolitics and International Research Collaboration*, "SSRN Electronic Journal", https://doi.org/10.2139/ssrn.5102499

Yoon, J., Yang, J.S., Park, H.W. (2017), *Quintuple helix structure of Sino-Korean research collaboration in science*, "Scientometrics", 113 (1), pp. 61–81, https://doi.org/10.1007/s11192-017-2476-x

Zakir Hossain, A.N.M. (2022), *Recent Development and Emerging Trends of Research on Rohingya Refugee Crisis (1993–2020): A Bibliometric Analysis*, "International Journal of Sustainable Development and Planning", 17 (3), pp. 849–862, https://doi.org/10.18280/ijsdp.170315

Zhang, C., Liu, N. (2024), *Innovation intermediaries: a review, bibliometric analysis, and research agenda*, "The Journal of Technology Transfer", 49 (3), pp. 1113–1143, https://doi.org/10.1007/s10961-023-10030-0

Zhang, L., Cao, Z., Sivertsen, G., Kochetkov, D. (2024), *The influence of geopolitics on research activity and international collaboration in science: the case of Russia*, "Scientometrics", 129 (10), pp. 6007–6021, https://doi.org/10.1007/s11192-024-04984-7

Zhang, Y., Chen, K., Fu, X. (2019), *Scientific effects of Triple Helix interactions among research institutes, industries and universities*, "Technovation", 86–87, pp. 33–47, https://doi.org/10.1016/j.technovation.2019.05.003

Zhao, D., Strotmann, A. (2022), *Intellectual structure of information science 2011–2020: an author co-citation analysis*, "Journal of Documentation", 78 (3), pp. 728–744, https://doi.org/10.1108/JD-06-2021-0119

Zhao, Z., Bu, Y., Li, J. (2022), *Does the mobility of scientists disrupt their collaboration stability?*, "Journal of Information Science", 48 (2), pp. 199–209, https://doi.org/10.1177/0165551520948744

Międzynarodowa współpraca B+R w odpowiedzi na globalne zakłócenia: porównawcza bibliometryczna analiza sieci badawczych

W niniejszym badaniu analizowana jest międzynarodowa współpraca badawczo-rozwojowa (B+R) związana z globalnymi kryzysami lub zakłóceniami, ze szczególnym uwzględnieniem jej roli w rozwiązywaniu problemów wynikających z różnorodnych kryzysów. Analiza bibliometryczna 160 recenzowanych artykułów pozwoliła zidentyfikować wzorce współpracy i nakreślić mapę globalnych sieci badawczych. Zastosowano porównawcze ramy analityczne, aby zbadać różnice w tematyce i formach współpracy badawczej w różnych typach zakłóceń lub kryzysów. Wyniki pokazują, że współpraca badawczo-rozwojowa związana z zakłóceniami koncentrowała się w ośrodkach badawczych, takich jak Stany Zjednoczone, Wielka Brytania i Niemcy, z najsilniejszymi powiązaniami między Stanami Zjednoczonymi a Chinami oraz między Chinami a Wielką Brytanią. Pozostałe kraje zajmują bardziej peryferyjne pozycje w globalnych sieciach współpracy, co znajduje odzwierciedlenie w relatywnie mniejszym zaangażowaniu w badania nad tym tematem. W Europie Środkowo-Wschodniej Czechy

wyróżniają się jako jeden z niewielu krajów, których działalność badawcza dotycząca współpracy w czasach turbulencji jest widoczna na arenie międzynarodowej. Ustalono także, że istniejące sieci powiązań między ośrodkami naukowymi prowadzącymi takie badania są najczęściej bilateralne, niedostatecznie reprezentowani są w tych sieciach badacze z krajów Europy Środkowo-Wschodniej i krajów Globalnego Południa. Zidentyfikowano sześć obszarów tematycznych związanych z kryzysami lub zakłóceniami, w których rozwijała się współpraca B+R: kryzysy środowiskowe, zagrożenia dla zdrowia publicznego, zmiany technologiczne, kryzysy ekonomiczne i finansowe, niestabilność instytucjonalna oraz wyzwania humanitarne.
Wyniki analiz, identyfikując wzorce międzynarodowej współpracy badawczo-rozwojowej związanej z wydarzeniami destabilizującymi, mogą inspirować do skuteczniejszych reakcji na globalne wyzwania oraz wspierać rozwój bardziej odpornych i reagujących na kryzysy strategii badawczo-rozwojowych.

Słowa kluczowe: międzynarodowa współpraca B+R, kryzysy i niepewność, innowacja motywowana kryzysem, analiza bibliometryczna, przegląd literatury