Journal of Infrastructure, Policy and Development 2024, 8(8), 6155.
https://doi.org/10.24294/jipd.v8i8.6155

Article

Bibliometric analysis of the Japan-Russia scientific cooperation networks using R bibliometrix

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CITATION

Boiarskii B, Lyude A, Boiarskaia A, et al. (2024). Bibliometric analysis of the Japan-Russia scientific cooperation networks using R bibliometrix. Journal of Infrastructure, Policy and Development. 8(8): 6155. https://doi.org/10.24294/jipd.v8i8.6155

ARTICLE INFO

Received: 1 May 2024
Accepted: 28 May 2024
Available online: 26 August 2024

Abstract: Bibliometric analysis is a commonly used tool to assess scientific collaborations within the researchers, community, institution, regions and countries. The analysis of publication records can provide a wealth of information about scientific collaboration, including the number of publications, the impact of the publications, and the areas of research where collaborations are most common. By providing detailed information on the patterns and trends in scientific collaboration, these tools can help to inform policy decisions and promote the development of effective strategies to support and enhance scientific collaborations between countries. This study aimed to analyze and visualize the scientific collaboration between Japan and Russia, using bibliometric analysis of collaborative publications from the Web of Science (WoS) database. The analysis utilized the bibliometrix package within the R statistical program. The analysis covered a period of two decades, from 2000 to 2021. The results showed a slight decrease in co-authored publications, with an annual growth rate of −1.26%. The keywords and thematic trends analysis confirmed that physics is the most co-authored field between the two countries. The study also analyzed the collaboration network and research funding sources. Overall, the study provides valuable insights into the current state of scientific collaboration between Japan and Russia. The study also highlights the importance of research funding sources in promoting and sustaining scientific cooperation between countries. The analysis suggests that more efforts in government funding are needed to increase collaboration between the two countries in various fields.

Keywords: bibliometric; Web of Science; Japan; Russia; collaboration; open data; R bibliometrix

1. Introduction

When it comes to assessing the scientific potential of a particular scientific community, it is essential to take a closer look at their publication records. By conducting a thorough analysis of the scientific publications generated by researchers within the community, institution, or country, one can gain valuable insights into the research output and overall scientific impact (Abdullah, 2021; Aref et al., 2018; Boiarskii, 2022; Gautam, 2017). This systematic approach provides a reliable and objective means of evaluating the quality and quantity of research being produced and can help to identify areas of strength and weakness within the scientific community. Ultimately, such analysis is essential for ensuring that research funding and resources are being allocated effectively and that scientific progress is being made in a meaningful and impactful way (Abdullah et al., 2023; Aref et al., 2018; Fung and Wong, 2017; Gautam, 2017). Policymakers can use bibliometric insights to develop evidence-based policies that support scientific research and innovation. By understanding the landscape of scientific production, policies can be tailored to promote areas with high potential and address systemic issues that may hinder research progress (Cañas-Guerrero et al., 2013).

Examining the publication records of a scientific community can provide valuable insights into their research pursuits, output, and proficiency. By scrutinizing these records, researchers can glean information about the most thriving areas of research within the community, identify the most influential researchers, and assess the impact of their work on the wider scientific landscape. This approach enables a comprehensive understanding of the scientific community and can facilitate the development of future research agendas and collaborations (Boiarskii, 2022; Lyude et al., 2021; Moed et al., 2018).

Bibliometric research offers benefits for both science and practice. By analyzing citation networks and publication records, bibliometric research helps in pinpointing seminal works and leading authors in a field. This recognition not only highlights key contributions but also guides new researchers towards important literature and potential mentors. Identifying key collaborators and understanding the structure of research networks can facilitate the formation of new partnerships and interdisciplinary projects, boosting collaborative efforts and cross-pollination of ideas (Cañas-Guerrero et al., 2013; Fu et al., 2022; Lyude et al., 2021).

The Web of Science database offers comprehensive coverage of high-quality journals, including selection criteria and citation analysis tools. Its extensive historical data facilitates long-term studies, while advanced search capabilities enable precise and targeted research inquiries. Moreover, the database's interdisciplinary reach supports a broad spectrum of research fields, making it well-suited for comprehensive bibliometric studies (Gautam, 2016).

The bilateral scientific relations between Russia and Japan have gained momentum since the beginning of the 21st century. This progress was made possible by establishing a legal framework by signing the agreement on the Committee on Scientific and Technical Cooperation (CSTC) in September 2000 (MOFA, 2000). The agreement facilitated the exchange of scientific and technological knowledge on a mutually beneficial basis. It is important to mention that Russia and Japan held their first Cooperation Committee meeting in 1993 (MOFA: Japan's Assistance Programs for Russia, 2001). This meeting marked a significant milestone in the establishment of intergovernmental scientific and technical relations between the two nations. The discussions during the meeting covered various scientific topics, which set the groundwork for future collaborations between Japan and Russia (The Embassy of the Russian Federation in Japan, 2021). In a 2000 meeting, the two countries agreed to facilitate contacts and cooperation between research and educational institutions, organize joint events such as seminars, conferences, symposiums, and exhibitions, and exchange technologies. The top priority was on developing human resources, including the exchange of scientists, academic staff, students, graduate students, and other specialists involved in education and research

(MOFA, 2000).

Overall, the scientific relations between Russia and Japan have been steadily growing over the years, and both countries have been actively collaborating in various fields of science and technology. The cooperation has not only generated mutual benefits but also contributed to the advancement of the global scientific community (Lyude et al., 2021).

The Ministry of Economy, Trade and Industry (METI) in Japan has formed a bilateral agreement with the Ministry of Foreign Affairs (MOFA), the Cabinet Office (CAO), and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) to collaborate on various initiatives. The aim of this partnership is to foster cooperation and promote mutual understanding between Japanese and Russian nations. The Ministry of Science and Higher Education of the Russian Federation (MON) has been tasked with overseeing the activities from the Russian end, ensuring that the terms of the agreement are met in a fair and efficient manner. This joint effort reflects the commitment of both countries to strengthen ties and create opportunities for growth and innovation in various fields (Boiarskii, 2022; Ministry of Science and Higher Education of the Russian Federation, 2019).

Through utilizing the R bibliometrix tool, we conducted a thorough analysis of the primary data derived from the WoS databases. This comprehensive approach allowed us to obtain a detailed investigation of the scientific collaboration between Russia and Japan, focusing on the publication of co-authored articles in various scientific fields. The study provides a comprehensive analysis of the scientific collaboration between Russia and Japan, examining factors such as publication counts, research topics, institutional involvement, and funding agencies. Despite the increase in co-authored articles, it concludes that the level of bilateral scientific collaboration between the two countries has remained largely stagnant. In future research, authors will explore specific topics and areas within this context to gain a deeper understanding of the collaborative efforts between the two countries.

2. Materials and methods

Bibliometric analysis of publications has recently been prevalent in studying the knowledge intensity of articles, researchers, institutions, and countries (Donthu et al., 2021; Kholidah et al., 2022). This method determines both qualitative and quantitative indicators (Ellegaard and Wallin, 2015; Moral-Muñoz et al., 2020). Bibliometrics helps assess scientific activity in more detailed and accessible based on computer statistical calculations (Aria and Cuccurullo, 2017). The bibliometric analysis evaluates publication activity over a period of time, topics and disciplines studied, and assesses the contributions of authors and societies to the global scientific network (Briner and Denyer, 2012).

The previous study showed the use of various tools for bibliography analysis, such as R bibliometrix using the R language (Abbas et al., 2022; Aria and Cuccurullo, 2017; Boiarskii, 2022; Dervis, 2019; Guleria and Kaur, 2021), VOSviewer (Abdullah, 2021; Guleria and Kaur, 2021; Kholidah et al., 2022), Content Analysis Toolkit for Academic Research (CATAR) (Fu et al., 2022; Tseng and Tsay, 2013; Yeh et al., 2022). These tools provide researchers with powerful functionalities to conduct in-depth bibliometric analyses, visualize research networks, and gain insights into publication patterns and trends. By combining the capabilities of these tools, researchers can perform comprehensive analyses of scientific collaborations, identify influential publications, and uncover emerging research areas.

In this study, the collaboration between Russia and Japan in the Web of Science Core Collection publication databases was analyzed from 2000 to 2021. The research encompassed 5673 documents from 1422 sources, consisting of 4666 articles, 896 proceedings papers, and 111 review articles. The authors conducted a comprehensive analysis of the efficacy of written works over a specified duration, utilizing advanced tools such as WordCloud and Thematic map visuals to identify and highlight discernible themes and patterns. Additionally, the authors conducted an investigation into the primary funding agencies that provided support for the collaborations featured in publications. The information retrieved from the database of WoS has been compiled and is now being shown in the form of **Figure 1**.

Figure 1. The main information of the WoS databases analyzed by using the R bibliometrix tool (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

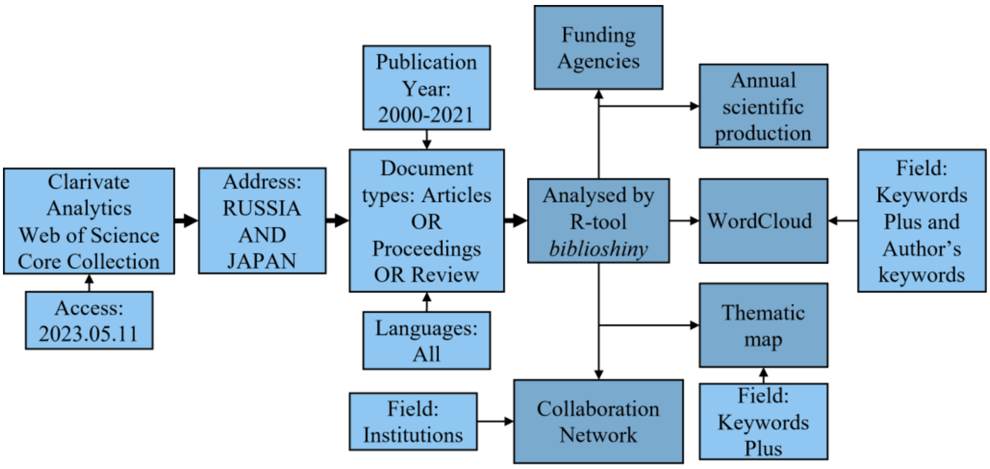

Figure 2. Workflow of data mining and construction.

The data for this study was obtained through the Clarivate database search engine at https://www.webofscience.com/wos/woscc/basic-search on 11 May 2023. Access was obtained through Niigata University, Japan. The detailed WoS URL with the Boolean operation set up is at the following web key link: https://www.webofscience.com/wos/woscc/summary/a7fccef1-d75b-4329-be86-b8fb2c0901ab-e8365dd2/relevance/1. The results obtained were exported to BibTex format with a complete set of records. The database analysis was carried out in the statistical program R version 4.1.0. The bibliometrix tool (Aria and Cuccurullo, 2017) was used, namely a web-interface app biblioshiny (Abbas et al., 2022; Moral-Muñoz et al., 2020). R bibliometrix is an R package specifically designed for bibliometric analysis. It provides functions for data retrieval, cleaning, and processing of bibliographic data from various sources, including WoS, Scopus, and PubMed. R bibliometrix offers a range of bibliometric indicators and facilitates co-authorship network analysis, citation analysis, and mapping of scientific landscapes (Aria and Cuccurullo, 2017). **Figure 2** shows the data mining and analysis workflow.

3. Results and discussion

3.1. Scientific production

In the previous study, it was revealed that there has been a consistent rise in the number of articles co-authored by Japanese authors with other countries from 1997 to 2020 (Lyude et al., 2021). Japan has been actively engaged in international scientific collaborations, particularly in fields such as physics, materials science, chemistry, and biomedical research. Furthermore, institutions like the University of Tokyo, Kyoto University, and Tohoku University have been at the forefront of establishing and strengthening collaborative networks with researchers and institutions from around the world. These institutions actively promote research partnerships and academic exchanges, which can lead to an increase in co-authored publications (JSPS, 2024; Lyude et al., 2021). The Japanese government, through organizations such as the Japan Society for the Promotion of Science (JSPS) and various research funding agencies, has implemented initiatives to support and facilitate international collaborations (JSPS, 2024).

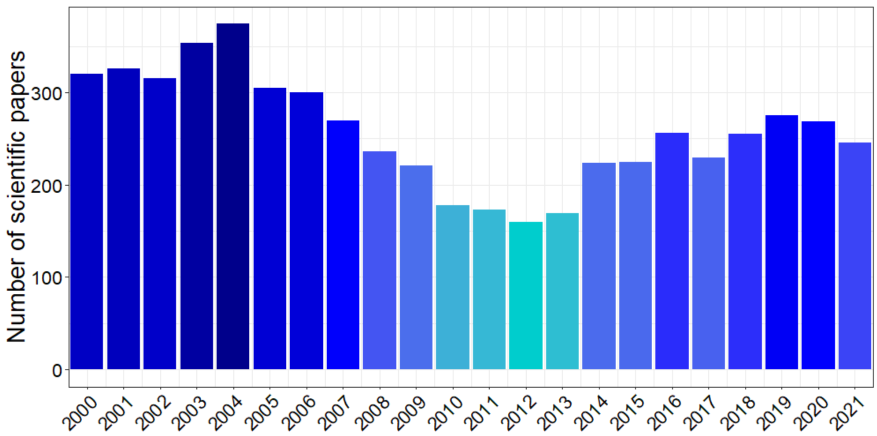

Figure 3. Annual scientific production between Japan and Russia from 2000 to 2021 years (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

The present study results reveal that bilateral co-authorship between Russia and Japan remains stagnant despite a persistent increase in multilateral scientific collaboration. **Figure 3** represents the total number of publications involving collaboration between Japan and Russia for each respective year. It’s important to note that these numbers do not differentiate between co-authored publications and publications solely authored by researchers from either Japan or Russia. The data indicates fluctuating publication activity throughout the years, with varying levels of collaboration between the two countries. The highest publication count was observed in 2004 with 374 records, while the lowest count was seen in 2012 with only 159 records. During the two decades from 2000, the annual growth rate in bilateral scientific collaboration decreased insignificantly, of −1.26% (**Figure 3**). A surge in publication activity occurred from the year 2000 following the establishment of the Committee on Scientific and Technical Cooperation (CSTC) agreement between Japan and Russia in September 2000. However, the profound impact of the Global Financial Crisis led to a decline in publishing activity from 2005, reaching its lowest point during the period of 2010–2013 (Boiarskii, 2022). Due to a decrease in financial resources, scientific organizations faced substantial budget cuts, which consequently hindered their ability to fully engage in and support various research initiatives and projects.

In 2013, the Russian Federation initiated a comprehensive reform of the country's academic system. This reform involved the amalgamation of three state academies under the Russian Academy of Sciences, the Russian Academy of Medical Sciences, and the Russian Academy of Agricultural Sciences, along with the simultaneous reorganization of their subordinate scientific institutes (Boiarskii, 2022; Dezhina, 2020). The reform resulted in an increase in the requirement for academic publications as a component of the obligatory evaluation criteria for research institutions.

3.2. WordCloud

Word clouds can be used to visualize key themes or topics that emerge from a collection of scientific literature. They can provide a quick overview of the most frequently mentioned keywords or phrases, highlighting the main focus areas of the research. However, while word clouds are useful for providing a high-level overview, they lack the ability to provide detailed insights or to show the relationships between different words or themes (Mulay et al., 2020; Patil et al., 2023).

The visualization presented in **Figure 4** offers a comprehensive overview of the most commonly used keywords in publications between Japan and Russia. The size of each word is proportional to its frequency of occurrence, with the larger words indicating a higher frequency of usage. The keywords that are positioned closer to the center of the cloud are more frequently used than those farther away. Upon closer analysis, it becomes evident that the main areas of research explored in these scientific publications are physics, chemistry, and material science (Lyude et al., 2021). These fields seem to dominate the research landscape, as evidenced by the high frequency of occurrence of relevant keywords. Overall, this visualization provides valuable insights into the scientific collaboration between Japan and Russia, shedding light on the key areas of research that have been explored in this context.

The most popular KeyWords Plus were "dynamics," "model," and "temperature," with the frequency of use 165, 133, and 131, respectively (**Figure**

4A). These keywords are fundamental concepts in areas such as physics, chemistry, material science, and environmental studies, making them relevant to a broad range of research topics. In the context of Russia-Japan collaboration, these areas are particularly significant as both countries have strong research traditions in physics, chemistry and material science. The KeyWords Plus consists of words or phrases from the titles of an article's references (Garfield, 1990) and are generated by the Web of Science platform algorithms.

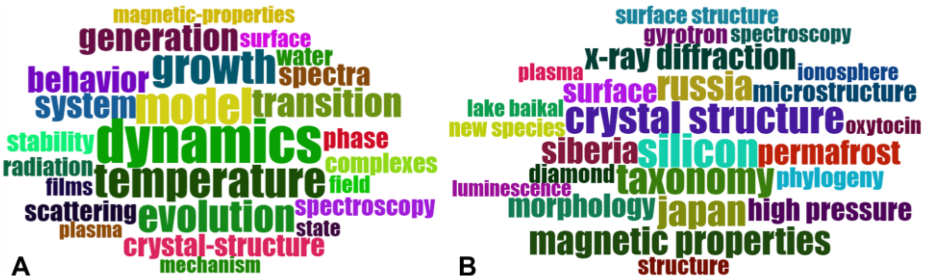

Figure 4. WordCloud figures of the most frequently used keywords in publications between Russia and Japan; **(A)** KeyWords Plus®; **(B)** authors' keywords (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

The authors' keywords provided by authors themselves are "silicon," "crystal structure" and "taxonomy" with usage frequency of 36, 34 and 33, respectively (**Figure 4B**). Several regionally bounded keywords such as "Japan," "Siberia," "Russia," "Hokkaido," "Lake Baikal," and "taiga," have appeared in the Authors' keywords section. The regional focus of the studies highlights the geographical areas where the research is conducted or which are the subjects of the research. This is particularly important in studies related to environmental science, ecology, and regional development. The authors themselves have included these region-specific keywords as part of their self-selected keywords. The presence of these regionally bounded keywords in the Authors' keywords section confirms that the WoS-generated KeyWords Plus® provides a different description of themes. This finding indicates that the automated keyword generation tool used by WoS, known as KeyWords Plus®, generates additional keywords that may differ from the authors' self-selected keywords.

By considering both the authors' self-selected keywords and the WoS-generated KeyWords Plus®, researchers can gain a more comprehensive understanding of the themes and topics covered in the analyzed publications. It highlights the importance of using multiple sources of information, including both author-provided keywords and automated keyword generation tools, to capture a broader range of relevant keywords and themes.

3.3. Thematic map

In the context of bibliometrics, a thematic map is a graphical tool used to represent the conceptual structure of a scientific field. It is usually built based on co-word network analysis and clustering, providing a visual representation of the major themes or topics in the analyzed documents, their relationships, and their centrality and density in the overall dataset (Büyükkidik, 2022). The density measures the value of the theme's development in the internal network. Centrality characterizes the importance of the theme in the development of the entire analyzed dataset. In other words, centrality measures the interaction of a network with other networks (Cobo et al., 2011).

Four quadrants consist of niches, motor, emerging, and basic themes. Niche themes make up a well-developed cluster within closely related keywords but are comparatively underdeveloped in relation to the entire network. Motor themes are well-developed in density and centrality and make up the entire network. Emerging topics are weak in both parameters and can reflect either new or disappearing ones. Basic themes are an underdeveloped cluster but are common throughout the network and are transversal.

Figure 5 shows themes that consist of KeyWords Plus clusters that can be analyzed according to the quadrant they belong to, based on their density and centrality. The theme "dynamics" is the most mature and prevalent, falling into the category of Motor themes. As expected, this theme is associated with physics, which is a primary area of co-authorship research between Russia and Japan. Themes such as "transition," "temperature," and "evolution" are Basic themes, they are less developed but interconnected with the entire network. These themes are versatile and could be applied to any research area. Themes like "model," "water," and "growth" are Niche themes, highly developed but isolated. The theme "combustion" represents the fourth quadrant, indicating an emerging or declining topic since it exhibits neither substantial development nor significant connections within the network.

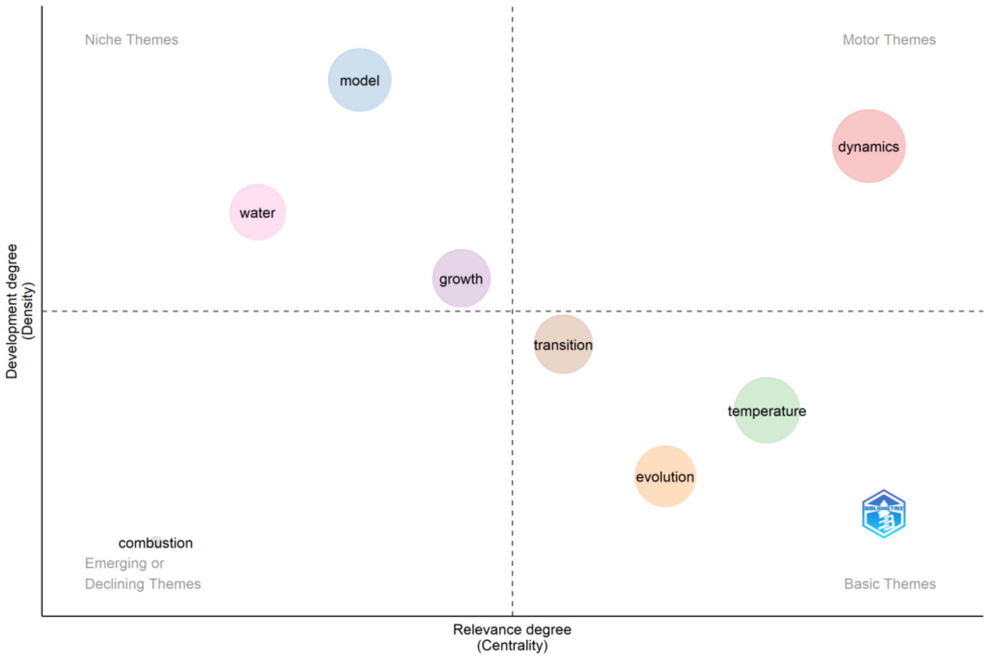

Figure 5. Thematic map (Key-Words Plus®)—Placed themes according to their density and centrality in four quadrants (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

As depicted in **Figure 6**, the themes are grouped into clusters based on the authors' keywords, and their placement in the quadrant is determined by their density and centrality. Same as the previous KeyWords Plus thematic map, four distinct types of themes can be observed—Motor, basic, niche, and emerging or declining.

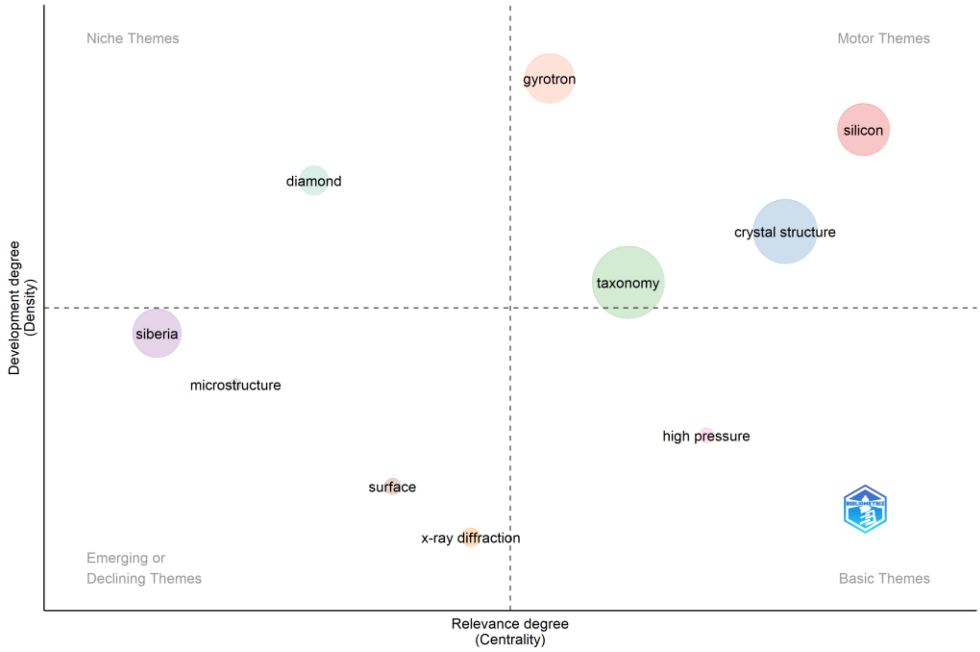

Figure 6. Thematic map (Authors' keywords)—Placed themes according to their density and centrality in four quadrants (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

The most mature and widespread themes include "gyrotron," "silicon," "crystal structure," and "taxonomy". These fall into the category of Motor themes, which exhibit high density and centrality, indicating their integral role in the network of keywords. The "transition" theme falls into the basic category. Basic themes are less developed but are interconnected throughout the entire network. This versatility allows them to be applied across various research areas, enabling broader connections and interactions within the scientific discourse. The "diamond" theme is classified as a niche theme. Niche themes are highly developed within their own clusters, but they remain isolated from the rest of the network. These themes represent specific areas of intense focus or specialized research that may not extensively intersect with other research areas. Finally, the themes "Siberia," "microstructure," "surface," and "X-ray diffraction" are characterized as either emerging or declining. These themes neither exhibit substantial development nor form significant connections within the network. This may suggest that these areas are either in the early stages of development or are on a downward trajectory, potentially reflecting shifts in research focus or the natural evolution of scientific exploration.

In conclusion, these findings underscore the diversity and dynamics of scientific collaboration between Japan and Russia. While certain research areas are strongly represented and interconnected, there are also fields of specialized focus and potential emerging or declining topics. This comprehensive understanding can inform policy decisions, guide future research directions, and foster the development of collaborative efforts in areas of mutual interest.

3.4. Co-occurrence network

Utilizing a co-occurrence network of keywords, we investigate specific topics that underscore the cooperation between the two countries. This approach allowed us to visualize the interconnectedness of various research themes, as reflected by the co-occurrence of keywords in the published literature (Büyükkidik, 2022). By mapping these relationships, we were able to discern clusters of keywords that often appear together, suggesting a focused collaboration on these specific areas of research.

The co-occurrence network of KeyWords Plus keywords shows prominent clusters, each led by the keywords “evolution,” “temperature,” and “dynamics”. This implies that these three keywords are central to the largest themes or topics within the analyzed dataset. These clusters suggest that the co-authorship research between Japan and Russia is largely centered around these themes (**Figure 7**).

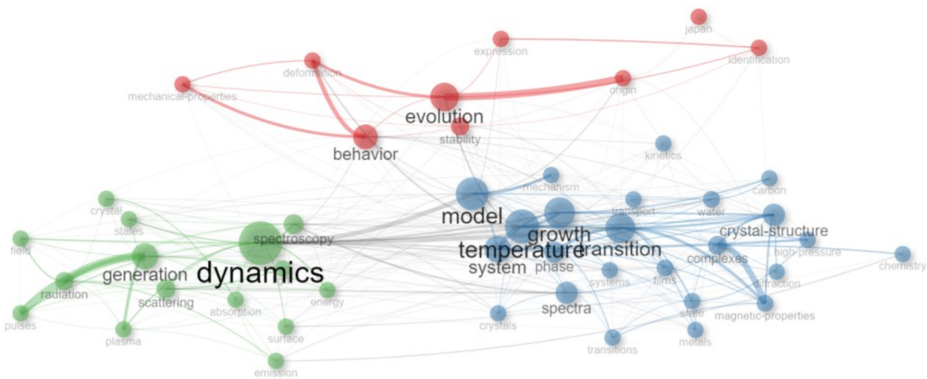

Figure 7. Co-occurrence network. KeyWords Plus® (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

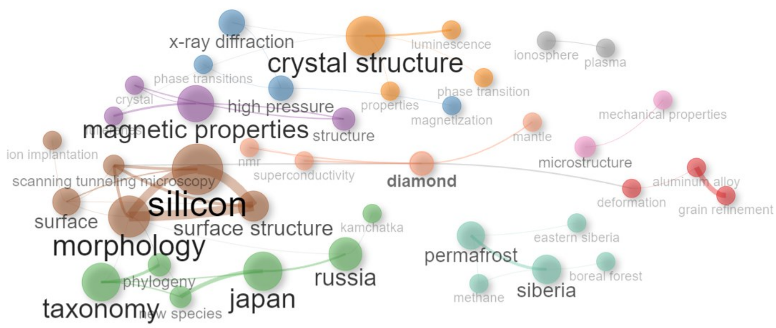

Figure 8. Co-occurrence network. Authors’ keywords (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

Figure 8 shows the co-occurrence network with keywords provided by the authors of the articles. They are chosen based on what the authors believe are the most important concepts, methods, or topics in their work. The main clusters are led by "crystal structure," "silicon," "magnetic properties," "taxonomy," "Siberia" and others.

The keywords "Japan," "Russia," and "Kamchatka" cluster together in a co-occurrence network, which suggests that these terms often appear together in the same articles. "Kamchatka" is a peninsula in the Russian Far East, and its close proximity to Japan makes it a common area of interest for bilateral research between the two countries. Given these keywords, it's likely that these papers involve research topics related to this geographical area. These could include a wide range of disciplines, such as studies in geology, ecology, marine biology, and climate science.

The cluster that includes "silicon," "morphology," "surface," and "surface structure" likely refers to research in the field of material science or physical chemistry. These studies could be related to the properties of silicon and its potential applications, possibly in the field of semiconductors or nanotechnology. The cluster that includes "magnetic properties," "structure," and "crystals" is indicative of research in the field of solid-state physics or materials science. This aligns with the previous finding that physics is a leading topic of cooperation between Japan and Russia. The co-occurrence network of keywords can provide more granularity, highlighting the specific areas within physics that these collaborations tend to focus on.

As for the clusters with minor words connected to each other, these could represent more niche or specialized areas of research collaboration. Each cluster in a co-occurrence network represents a group of keywords that frequently appear together in the same set of papers, so the specific research topics would depend on the keywords in each cluster.

KeyWords Plus and Author's keywords serve different purposes and are derived in different ways, which can result in different clusters appearing in co-occurrence networks. Because of these differences, the co-occurrence networks of Authors' keywords and KeyWords Plus can look quite different. Authors' keywords might reflect more specific or niche topics, while KeyWords Plus might capture broader themes or concepts that are prevalent across many articles. In this study, the clusters around "crystal structure," "silicon," "magnetic properties," "taxonomy," and "Siberia" suggest that these are important themes in the authors' view of their own research. On the other hand, the KeyWords Plus clusters around "evolution," "temperature," and "dynamics" suggest that these are broader themes that are prevalent in the research field as a whole, as derived from the titles of cited articles, as was described above.

In summary, the differences in the co-occurrence networks of these two keyword types reflect the different perspectives they provide on the research. One is more author-focused (authors' keywords) and the other is more field-focused (KeyWords Plus), providing a more comprehensive view of the research landscape.

3.5. Collaboration network—Institutions

The collaboration network depicted in **Figure 9** visualizes the institutions from

Japan and Russia that have participated in co-authoring publications. A total of 25 nodes represent these institutions, with the size of each node correlating to the number of articles the institution has published. The thickness of the lines connecting the nodes denotes the number of articles co-published by the connected institutions.

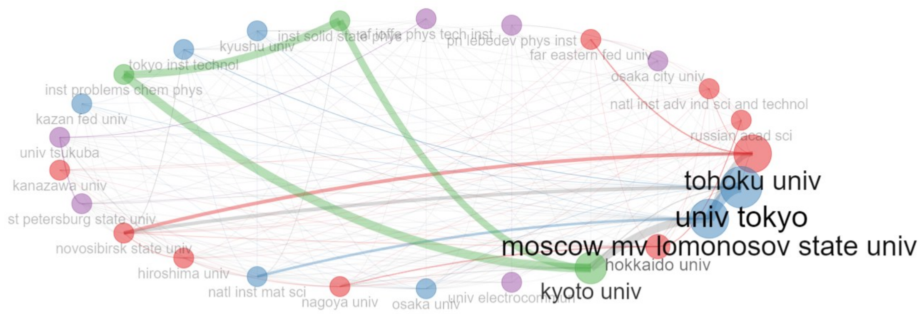

Figure 9. Collaboration network—Institutions: 25 Institutions with the most collaboration in publications between Japan and Russia (Source: Own calculation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

Four distinct clusters, represented in red, blue, purple, and green, emerge from this network. Among these, the largest nodes include leading academic institutions from both countries, such as the University of Tokyo and Tohoku University from Japan and Lomonosov Moscow State University from Russia. These institutions serve as primary contributors to the Agreement on Scientific and Technical Cooperation (MOFA, 2000). The red cluster, comprising nine nodes or institutions, demonstrates the highest degree of collaboration within the network and includes Tohoku University and Hokkaido University from Japan, Novosibirsk State University and Far Eastern Federal University from Russia. Despite this, the blue cluster exhibits a greater number of publications by a single institution, namely, the University of Tokyo and Lomonosov Moscow State University.

The green cluster, which includes Kyoto University, The Institute for Solid State Physics from Japan, and The Institute of Problems of Chemical Physics from Russia, displays the greatest collaboration intensity, as evidenced by the thickness of the lines connecting these institutions.

The purple cluster is less wide and consists of Osaka City University (Japan), The University of Electro-Communications (Japan), Lebedev Physical Institute (Russia), The Ioffe Physical-Technical Institute of the Russian Academy of Sciences (Russia), Saint Petersburg State University (Russia) and University of Tsukuba (Japan). Despite its smaller size, the purple cluster is a testament to the diverse and multi-institutional nature of the scientific collaboration between Japan and Russia.

3.6. Funding agencies

The primary funding agencies driving the bilateral collaboration between Japan and Russia are those tasked with the implementation of the Agreement on Scientific and Technical Cooperation. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan leads this effort, with 1408 records of funding (**Figure 10**). The Japan Society for the Promotion of Science (JSPS), Grants in Aid for Scientific Research (Kakenhi), and the Russian Foundation for Basic Research (RFBR) are also major contributors to the funding of collaborative research projects between the two countries, with 1295, 1102 and 890 records respectively. Their leading role can be traced back to 2007, when the two organizations, JSPS and RFBR, signed a bilateral memorandum. Following the memorandum, they have jointly funded competitive grants for research projects in diverse areas such as mathematics, physics, chemistry, biology, medicine, earth sciences, human and social sciences, and information technology, among others (The Embassy of the Russian Federation in Japan, 2021).

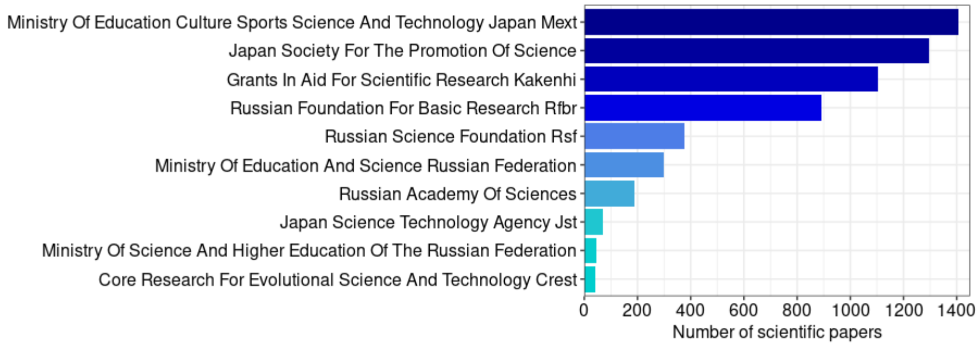

Figure 10. Primary funding agencies supporting Russia-Japan scientific collaboration (Source: Own calcu-lation using R software 4.2.2 (2022) based on the data aggregated by the Clarivate Analytics, WoS Core Collection).

It's notable that private funding organizations are not prominently represented despite the significant influence of business on the evolution of science and technology in Japan. This could be due to the fact that, while business representatives have been involved in the work of the CSTC as observers since 2001, their contributions might not directly translate into the funding of specific research projects (MOFA, 2000).

Other prominent funding agencies include the Russian Science Foundation (RSF), with 375 records, the Ministry of Education and Science of the Russian Federation, with 300 records, and the Russian Academy of Sciences, with 187 records (**Figure 10**). The Japan Science and Technology Agency (JST) and the Core Research for Evolutional Science and Technology (CREST) also contribute to the funding landscape, though to a lesser extent, with 72 and 42 records, respectively. This distribution of funding underlines the committed support from both government and non-government organizations in fostering scientific cooperation between Japan and Russia.

The Ministry of Science and Higher Education is also involved, albeit with a smaller record count of 46. On 15 May 2018, the Russian government decided to split its Ministry of Education and Science into two new departments: the Ministry of Education, responsible for primary and secondary education, and a new, separate Ministry of Science and Higher Education (Allakhverdov, 2018). Thus, any statistics attributed to the former Ministry of Education and Science would not continue to accumulate under that name.

Scientists from Japan and Russia have successfully participated in multinational projects under the auspice of JST. JST works through the Strategic International Collaborative Research Program (SICORP), launched in 2009 based on inter-ministerial agreements with countries and regions and in S&T research fields that MEXT Japan has strategically prioritized. For the bilateral co-funding projects in the JST SICORP framework, in 2019, a partnership in the field of "Rational nature management including Arctic Research" and "Energy efficiency" was launched. The funding agency of the Russian side is the Ministry of Science and Higher Education of the Russian Federation (MON) (Strategic International Collaborative Research Program, 2019).

Within the SICORP framework, both countries also cooperate in "The e-ASIA Joint Research Program (e-ASIA JRP)," a joint initiative aimed to benefit from the merits of multilateral research collaboration, in 2012. Member organizations are public funding institutions of 10 ASEAN member countries + 8 (Australia, Japan, New Zealand, China, India, Korea, Russia, USA). From the Japan side MEXT, JST, and AMED are in charge, from Russia, RFBR is participating (e-ASIA JRP, n.d.).

Agriculture is another field where an official partnership between the Russian Science Foundation and the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) in December 2016 quickly stimulated the development of research cooperation between Japan and Russia (Russian Science Foundation, 2017). It is expected that when all the nations' primary research funders, i.e., the Russian Science Foundation, Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan Science and Technology Agency (JST), and Japan Agency for Medical Research and Development (AMED), will launch further direct bilateral co-funding programs, it would significantly inspire joint research (Russian Science Foundation, 2017).

4. Limitations

While this study provides valuable insights into the nature and extent of scientific collaboration between Japan and Russia, it is important to consider limitations when interpreting the findings. The process of research, drafting, review, and publication of scientific articles can often take a significant amount of time. This means that the snapshot of data used in this study may not fully reflect the current state of scientific collaboration between Japan and Russia. Research conducted and papers written recently might still be in the process of peer review or awaiting publication, and therefore, the years 2022, 2023 and 2024 would not be included in this study.

The study also doesn't account for the impact of recent global issues, such as the COVID-19 pandemic, geopolitical tensions, or major shifts in funding priorities. These factors can significantly influence the pace and focus of scientific research and collaboration. It may take several years for the full impact of these events to be reflected in the publication database.

5. Conclusion

The study has shown that while the number of articles co-authored by Japanese and Russian authors has decreased overall, there has been a resurgence in scientific collaboration between these two countries in the period from 2013 to 2021. However, the level of bilateral scientific collaboration between the two countries has remained stagnant. This is despite an overall increase in international scientific collaboration by both countries, particularly in fields such as physics, materials science, chemistry, and biomedical research. The most common research areas explored are physics, chemistry, and material science. Regional keywords such as "Japan," "Siberia," and "Russia" were frequently used, indicating a focus on regional issues.

In the terms of institutional collaboration, universities such as the University of Tokyo, Tohoku University, and Lomonosov Moscow State University have played a pivotal role in fostering these partnerships, as demonstrated by their connects in the collaborative network. Additionally, the Japan Society for the Promotion of Science (JSPS) and the Russian Foundation for Basic Research (RFBR) stand out as the primary funding agencies driving forward this bilateral cooperation.

The authors believe that in order to develop an effective strategy for their cooperation, it's necessary to understand the motivations and expectations of the other side. The authors concluded that there is a need to develop a new framework for cooperation built on a balance of interests, mutual trust, and respect. They also highlighted the importance of the academic community in the two countries in contributing to the development of bilateral relations, for example, through the creation of joint scientific collaborations.

The ongoing research aims to collect additional data from the database and identify new patterns in international collaboration, particularly focusing on publication activity between Japan and Russia. In future studies, the research will delve into specific topics and research areas within this context to gain a deeper understanding of the collaborative efforts between the two countries.

Author contributions: Conceptualization, BB, AB and AL; methodology, BB and AB; software, BB and AB; validation, BB, AL and NO; formal analysis, BB and AB; investigation, AB; resources, AB; data curation, BB and AL; writing—original draft preparation, BB and AB; writing—review and editing, AL, NO and HH; visualization, BB and AB; supervision, NO and HH; project administration, HH; funding acquisition, AL. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: This work received partial support from JSPS KAKENHI Grant-in-Aid for Scientific Research (C) JP21K02628.

Data availability statement: Data available at: https://gist.github.com/Borissensei/2f6663b7b7ec8130b4e2abde7621b3f6

Conflict of interest: The authors declare no conflict of interest.

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