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A Bibliometric Analysis of Publications on University-Industry Collaboration Using VOSviewer and R-biblioshiny

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Abstract

This bibliometric analysis studied the development trends, publication and citation counts, research themes and trends, and international cooperation models related to university-industry collaboration from 1970 to 2023. Firstly, using a broader set of search terms related to university-industry collaboration, we conducted a comprehensive search of the global literature from 1970 to 2023 in the Web of Science (WoS) database. Secondly, based on inclusion and exclusion criteria, we ultimately selected 592 articles for analysis. Subsequently, we used VOSviewer and R-biblioshiny as analytical tools to extract and analyze relevant data from the selected articles. The study identified the most influential institutions, journals, authors, and countries in this field. Additionally, based on keyword co-occurrence analysis, research related to university-industry collaboration is distributed across five clusters: (1) innovation and technology transfer, (2) internships and work experience, (3) cooperative education and learning outcomes, (4) collaboration models and partnerships, and (5) collaboration barriers, challenges, and sustainability. Recent research has focused on themes such as technology transfer, barriers, benefits, and the motivations driving collaboration.

Keywords: university-industry collaboration; WOS; bibliometric study; VOSviewer; R-biblioshiny

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1. Introduction

To successfully achieve the Sustainable Development Goals, individuals, businesses, governments, and higher education institutions should collaborate closely (Llopis-Albert et al., 2022). University-Industry collaboration networks, recognized as increasingly significant to national economies (Borges et al., 2022; O' Dwyer et al., 2023), have become a focal point of research. The literature on this collaboration has experienced notable growth, reflecting its role as a driver of economic progress, innovation, and competitiveness (Borges et al., 2022; Skute et al., 2019). University-industry (U-I) research has evolved into a multifaceted and ambiguous research field, characterized by highly complex interconnections (Skute et al., 2019). Given the multidimensional nature of the U-I research domain, many scholars have conducted literature reviews on the research of university-industry collaboration, but with different emphases (Mascarenhas et al., 2018). For instance, the focus of studies such as Agrawal (2001) and Geuna & Muscio (2009) is on technology transfer, while Perkmann & Walsh (2007) emphasize the types of links between universities and/or companies and open innovation, Enke et al. (2021) verified the critical success factors in University-Industry collaboration.

This study conducts a bibliometric analysis of the "University-industry Collaboration" field using Vosviewer and R-Biblioshiny. Bibliometric analysis, as a research method, examines global research trends in specific fields based on academic publications (Alsharif et al., 2020). Bibliometrics is utilized as a technique for constructing information networks to address thematic issues within specific knowledge domains (Fahamsyah et al., 2023). As outlined by Van Eck & Waltman (2014), its aim is to uncover the primary themes in the field, their interrelations, and how they evolve over time. Bibliometric analysis provides an objective and quantitative assessment of research trends, influential publications, key contributors, and collaboration networks. Extending the line of prior studies, our research aims to offer a more thorough overview and trend analysis of disciplinary research in university-industry collaboration. This study distinguishes itself by achieving greater precision and comprehensiveness in both time span and search term selection, providing a nuanced and current understanding of collaboration dynamics.

This study aims to conduct a comprehensive bibliometric analysis to gain insights into the current research landscape of university-industry collaboration. The objectives are as follows:

1) Analyze the quantity and citation trends of publication in the university-industry collaboration field from 1970 to 2023, examining temporal dynamics.

2) Identify key journals, organizations, authors, and countries contributing to research in university-industry collaboration and assess their impact.

3) Identify researcher communities and their influence within the university-industry collaboration field using co-authorship network analysis.

4) Analyze the temporal dynamics of citations, including detecting citation trends, and identifying influential literature within different time periods.

5) Analyze international collaboration patterns to identify prevalent cooperative relationships between countries and their impact on scientific output.

6) Investigate themes and trends in university-industry collaboration research, including keyword analysis and topic identification.

7)Investigate the evolution of interdisciplinary collaboration by identifying areas of convergence between different research fields.

2. Literature Review

University-industry collaboration is considered an engine of innovation (Shi & Wang, 2023). Universities are crucial participants in this innovation system (Pereira & Franco, 2022). As firms have limited internal knowledge reserves and creation capabilities, external knowledge acquisition becomes increasingly important (Carayannis & Campbell, 2006). Scandura (2016) suggests that firms need to seek and utilize new sources of knowledge to innovate and grow, with universities typically being major reservoirs of such knowledge. Cross-boundary collaboration between universities and industries is achieved through knowledge sharing and transfer, creating synergies between the two that serve as competitive tools in the market (Anatan, 2015). Malik (2013) demonstrates that university-industry collaboration facilitates knowledge spillovers, offering other organizations within the region more opportunities to learn, grow, and engage in related innovation activities. Therefore, the essence of university-industry collaboration is a cross-organizational knowledge integration process aimed at innovation.

Graduates face challenges in finding respectable employment after university, highlighting the need to improve curricula through active partnerships between academia and industry to meet industrial demands (Sabando, 2023). Shegelman et al. (2015) prove that joint efforts between higher education and enterprises significantly enhance the professional level of university scientists, developers, teachers, and postgraduate students, while also increasing the quality and demand for graduates prepared to work efficiently in high-tech organizations within the real economy. Wirsich et al. (2016) argue that collaboration with universities is a powerful engine for technological development. Such cooperation brings substantial benefits to both industry and academia, including enhanced industrial innovation capabilities and the motivation and validation of research ideas in real-world settings (Marijan & Gotlieb, 2021).

Meanwhile, there are multiple challenges to University-Industry Collaboration (UIC) (Ćudić et al., 2022). Although UIC is beneficial for both parties, the prerequisite for successful collaboration is overcoming these necessary obstacles. Fernandes et al. (2022) identify several challenges to the successful implementation of UIC, the most significant being cultural differences between the collaborators. The organizational culture of companies, which is driven by profit, contrasts with the culture of universities, which is driven by the pursuit of knowledge and exploration of scientific principles, creating barriers to collaboration (Bergman, 2010). Additionally, differing goals between the two parties also pose significant obstacles. One of the most frequently discussed topics in UIC literature is the compatibility of partners' goals (Rybnicek & Königsgruber, 2019). Due to different societal roles and objectives, these goal differences can lead to collaboration barriers. In the knowledge economy environment, universities and companies have gradually increased the importance and awareness of knowledge ownership and protection (Bruneel et al., 2010). Excessive or unclear intellectual property rules hinder collaboration (Sjöö & Hellström, 2019). Therefore, disputes over intellectual property rights have become one of the barriers to UIC.

Some scholars have also conducted bibliometric analyses on the literature of university-industry collaboration. Mascarenhas et al. (2018) used VOSviewer to analyze the literature

on knowledge and technology transfer in university-industry collaboration from 1993 to 2016. Their results indicated that relevant research includes four clusters: absorptive capacity, knowledge and competitiveness in university-industry relations, the impact of knowledge spillover on university-industry relations, and strategic alliances for industrial innovation. Skute et al. (2019) examined the evolution and emerging patterns of university-industry (U-I) collaborations from 2011 to 2016, revealing the field's complexity and systematic clustering into individual, organizational, and institutional levels. Borges et al. (2022) utilized a bibliometric analysis to systematically review and map the literature on university-industry collaboration from 1970 to 2020, revealing a growing trend in research and highlighting key authors, research topics, and collaboration networks. Pujotomo et al. (2023) conducted a bibliometric analysis showing that research trends in the field of knowledge and technology transfer have evolved from the theme of the knowledge economy (2010-2013) to product development (2014-2015), technology commercialization (2016-2017), open innovation (2018-2019), and currently to the theme of green entrepreneurship. These bibliometric analyses collectively underscore the dynamic and multifaceted nature of university-industry collaboration research. The findings demonstrate the necessity of continued bibliometric analysis to map out the progression and emerging trends, thereby facilitating a comprehensive understanding of the evolving landscape of university-industry collaborations.

3. Materials and Methods

3.1. Search Strategy

The articles on university-industry collaboration were sourced from the Web of Science (WoS) database, accessed on November 24, 2023. This database is recognized for covering a broad range of relevant journals and peer-reviewed articles of high quality (Skute et al., 2019). The period covered spans from 1970 to 2023.

Considering the diverse terminology used by scholars for university-industry collaboration, we employed keywords "school industry partnership" OR "university industry cooperation" OR "Industry university partnerships" OR "academia industry cooperation" OR "universities industry collaboration" OR "cooperative education" OR "school enterprise cooperation" OR "school industry cooperation" OR "academia industry collaboration" OR "academia industry partnership" OR "school industry collaboration" OR "academia industry partnership" as the keywords for searching titles, abstracts and/or keywords while allowing for variations of term spelling (e.g., "school-industry partnership", "school/industry partnership" etc.). This keyword combination allows to grasp the literature scope at a broad level and minimizes the risk of including false positive items that do not compliment the actual thematic literature, potentially leading to misleading interpretations of the state of knowledge (Kovács et al., 2015).

3.2. Article Selection

The WoS database identified a total of 1,757 documents published on the topic of university-industry collaboration from 1970 to 2023. We focused our search on "articles" and "reviews articles" in the Web of Science database, excluding non-English papers. This process yielded a total of 592 articles, with 7,351 citations and 6,325 references (Figure 1). To ensure accuracy, we checked each article in our dataset for the inclusion of keywords or their variations in the title, abstract, and/or keywords, aiming to avoid false positives.

3.3. Data Extraction

Once the articles were selected, we extracted the following data for visualization and bibliometric analysis: author names, article titles, publication journals, keywords, organizational affiliations, publishing countries/regions, and the total number of citations.

3.4. Visualized and Bibliometric Analysis

VOSviewer and R-biblioshiny are two commonly used tools in bibliometric analysis. VOSviewer, a versatile software tool in scientometrics, is employed for constructing and visualizing bibliometric networks, allowing the analysis of relationships among authors, keywords, and publications, and providing features such as clustering and density mapping (Van Eck & Waltman, 2010). R-Biblioshiny, a Java software created by Massimo Aria from the University of Naples

Federico, integrates the capabilities of the bibliometrix package with the user-friendly interface of web applications within the Shiny package environment (Huang et al., 2021). After obtaining publications that align with the theme, the researchers exported the results in two file formats: CSV and Bibtex. The CSV files were analyzed using VOSviewer software, while the Bibtex files were utilized with biblioshiny. The following flowchart illustrates the bibliometric analysis methods employed in this study (Figure 1).

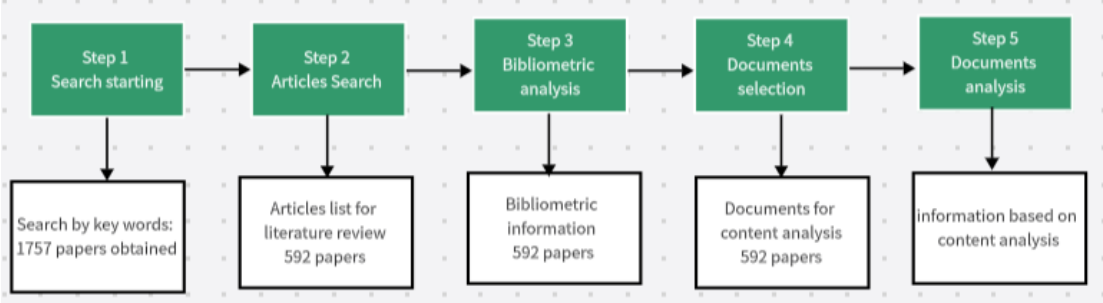

Figure 1. Search protocol (Mascarenhas et al., 2018)

4. Results

4.1. Trend Analysis of the Citations and Publications

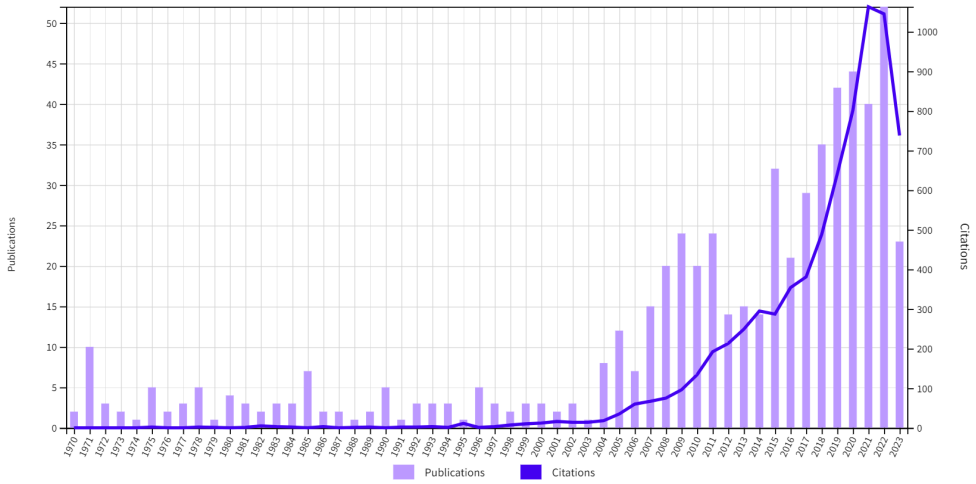

Figure 2. The number of publications and citations per year for 1970-2023

We obtained 592 English publications on university-industry collaboration. They were published from 1970 to 2023, with a total of 7351 citations, averaging 12.42 citations per publication. In recent years, both the number of papers and total citations have shown an overall increasing trend (Figure 2). Among them, papers published in the last five years (2019 to 2023) account for 33.95% of the total. The peak year for publications was 2022 (52 articles), and the peak year for citations was 2021 (1063 times).

Table 1-4 summarizes the top ten journals, organizations, authors, and countries related to "university-industry collaboration".

Table 1. Top 10 journals of "university-industry" publications

Journal	Number of documents	Count of citations
Asia Pacific Journal of Cooperative Education	76	984
International Journal of Work Integrated Learning	18	48
International Journal of Engineering Education	16	122
Engineering Education	15	9
Industry And Higher Education	13	83
Journal of The Knowledge Economy	8	112
Journal of Hospitality Tourism Education	7	39
Journal of Chemical Education	7	6
Journal of Engineering Education	6	1029
Higher Education	6	198

Table 2. Top 10 organizations of "university-industry" publications

Organization	Number of documents	Count of citations
University of Waterloo	29	334
Northeastern University	15	135
Auckland University of Technology	13	229
University of Waikato	12	303
University System of Ohio	10	26
State University System of Florida	9	354
Universidade Da Beira Interior	9	311
Purdue University	8	65
University of Cincinnati	8	22
University of Tartu	7	85

Table 3. Top 10 authors of "university-industry" publications

Author	Number of documents	Count of citations
Fleming, Jenny	12	220
Reinhard, Karin	10	60

Pretti, T. Judene	10	88
Drewery, David	7	53
Tanaka, Yasushi	6	0
Zegwaard, Karsten E	6	177
Eames, Chris W	5	101
Golab, Lukasz	5	20
Pennaforte, Antoine	5	32
Nevison, Colleen	5	47
Wild, Steffen	5	37

Table 4. Top 10 countries of "university-industry" publications

country	Number of documents	Count of citations
USA	127	2393
Peoples R China	76	665
Canada	56	767
Australia	47	882
Germany	33	689
New Zealand	28	583
Japan	25	223
England	23	765
Portugal	17	539
Spain	16	121

The journal with the highest number of publications is the "Asia Pacific Journal of Cooperative Education" with 76 articles and 984 citations. Although the "Journal of Engineering Education" has only 6 publications, it has the highest number of citations among the top ten journals on "university-industry collaboration," reaching 1029 (Table 1).

Among the top ten organizations, the "University of Waterloo" ranks first with 29 publications and 334 citations. The "State University System of Florida" ranks sixth in the number of publications with 9, but it has the highest number of citations among the top ten organizations, totaling 354 (Table 2).

Table 3 shows the top ten authors of "university-industry collaboration" publications. The number of publications ranges from 12 to 5. Jenny Fleming tops both the number of publications and citations (12 articles, 22 citations). Karin Reinhard follows closely, ranking second in the number of publications (10 articles). The second-highest in citations is Karsten E Zegwaard, with 6 publications and 177 citations.

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Table 4 shows the top ten countries of "university-industry collaboration" publications. The USA ranks first with 127 articles and 2393 citations, The second-highest is China with 76 articles. Australia contributed 47 publications, but its citations are 882, ranking second.

4.2 Analysis results of co-authorship

In the co-authorship network analysis, T. Judene Pretti from the University of Waterloo has the strongest co-authorship network, with a total link strength of 16. She is considered to have significant collaborative relationships with Drewery, Nevison, and Pennaforte. Their research focuses on the importance of work-integrated learning (WIL) and its impact on students, employees, and organizations, aiming to provide in-depth insights and practical value for understanding WIL. Additionally, Winchester-Seeto, Mackaway, and Coulson are also considered to have significant collaborative relationships. Their research explores various aspects of work-integrated learning, such as curriculum adjustments, role clarification, assessment design, and institutional capacity enhancement (Figure 3).

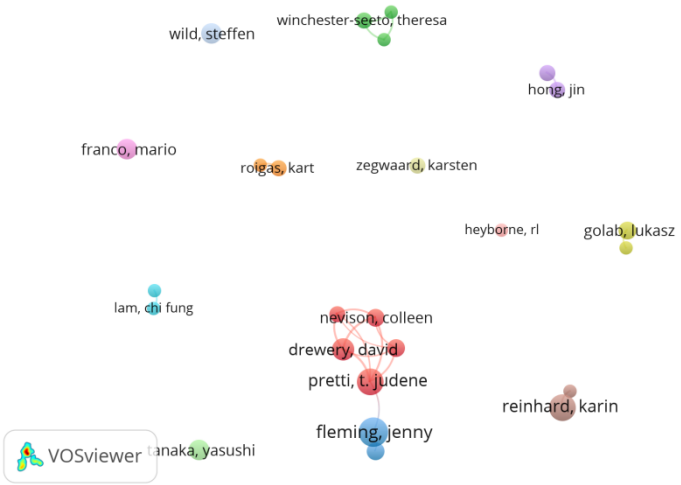

Figure 3. Visualization of author collaborations using VOSviewer

In this field, 699 institutions are involved. The University of Waterloo has 29 relevant articles and 334 citations, with the highest total link strength of 11. They collaborate with 7 institutions, and their research covers various aspects of school-enterprise cooperation, such as cooperative educational practices, student internships, and the impact of school-enterprise cooperation on

innovation. The University of Waikato has 12 related articles and 347 citations on the theme of school-enterprise collaboration, with a total link strength of 9. They also collaborate with 7 institutions, with Auckland University of Technology being their primary partner. Auckland University of Technology has the longest research tenure in this field, with a total link strength of 4 (Figure 4).

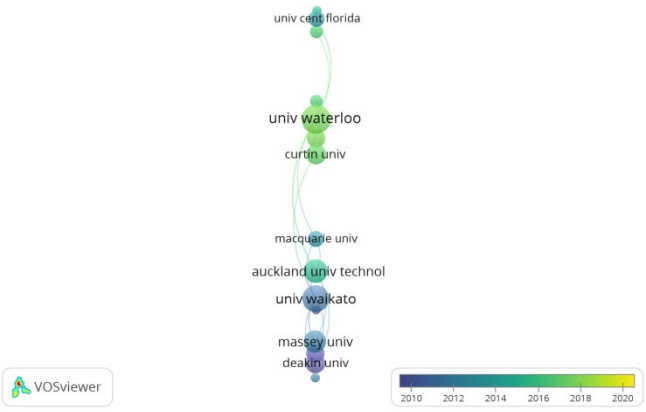

Figure 4. Visualization of institutional collaborations using VOSviewer

4.3 Analysis results of citations

The network visualization of literature citations showcases key publications within the identified 9 clusters: Rowe et al., (2012) with 37 citations, Ratinho & Henriques (2010) with 155 citations, Jackson (2013) with 87 citations, Ankrah & AL-Tabbaa (2015)) with 451 citations, Franco & Haase (2015) with 108 citations, Lee (1996) with 307 citations, Blair et al. (2004) with 55 citations, and Fleming et al. (2018) with 31 citations (Figure 5).

Rowe et al. (2012) introduces an Analysis and Reflection Tool to aid stakeholders in understanding and articulating the vital roles of host supervisors in experience-based and participatory learning, facilitating effective support for them in contexts such as cooperative education and work-integrated learning. Ratinho & Henriques (2010)explores the role of science parks and business incubators in promoting economic growth in Portugal, highlighting the importance of university links and effective management for their success in converging economies. Jackson (2013) examines the role of Work-Integrated Learning (WIL) in enhancing undergraduate

employability skills. Ankrah & AL-Tabbaa (2015) conducted a review of the organizational forms, motivations, and factors that facilitate or inhibit the operation of University-Industry Collaboration. Franco & Haase (2015) investigates the relationship between researchers" motivations and interaction channels in university-industry collaboration. Lee (1996) explores the evolving role of US academics in technology transfer for economic development, highlighting a shift towards greater openness to university-industry collaboration while also acknowledging concerns regarding academic freedom and the balance between research objectives and commercial interests.Blair et al. (2004) demonstrated significant effects of cooperative education programs on students" average grades, duration of enrollment, and starting salaries. Fleming et al. (2018) presents a framework for sustainable Work-Integrated Learning (WIL) relationships

Figure 5. Visualization of author citations using VOSviewer

4.4 Collaboration of Writers between Countries

The frequency of collaboration between the United States and Canada is the highest, totaling 11 instances. The collaboration frequency between the United States and China follows closely with 8 instances. The collaboration between Australia and New Zealand occurs 7 times, ranking third. The United States' collaborations with Canada, China, Australia, and other countries are notably frequent, highlighting their significant influence in this field (Figure 6). These collaborations involve aspects such as university-industry collaboration models, evaluation of cooperation outcomes, and policy research. Such cooperative relationships help to strengthen international exchange and collaboration in university-industry collaboration research, promoting the continuous development and deepening of university-industry collaboration theories and practices.

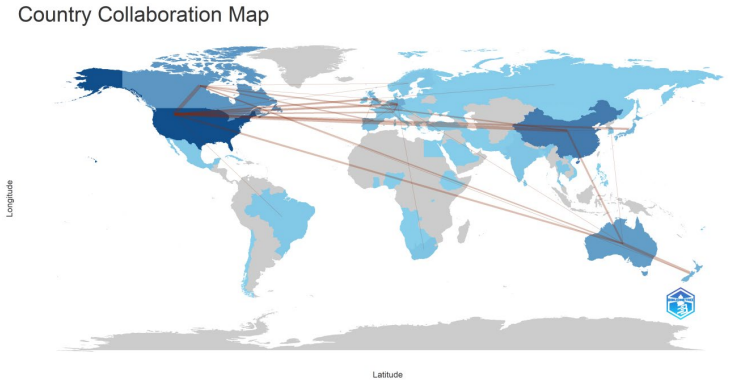

Figure 6. Country collaboration map with R-biblioshiny

We summarized the overall trends in university-industry collaboration measurement research involving countries, institutions, journals, and authors in Figure 7. Figure 7(a) depicts the connections between countries, journals, and institutions, with thicker lines indicating closer connections. The United States is the country with the most connections to journals and institutions, highlighting its significant position in this field. Most university-industry collaboration research is published in the Asia Pacific Journal of Cooperative Education, with a large portion authored by scholars from the University of Waterloo in the United States. Additionally, Figure 7(b) shows the interactions between the most active institutions, journals, and authors. The top active authors publishing high-quality papers come from institutions in the United States, Germany, and New Zealand. Figure 7(c) displays the interactions among active countries, institutions, and authors. Overall, the United States and the United Kingdom are leading in university-industry collaboration research, with high citation rates and high-quality papers.

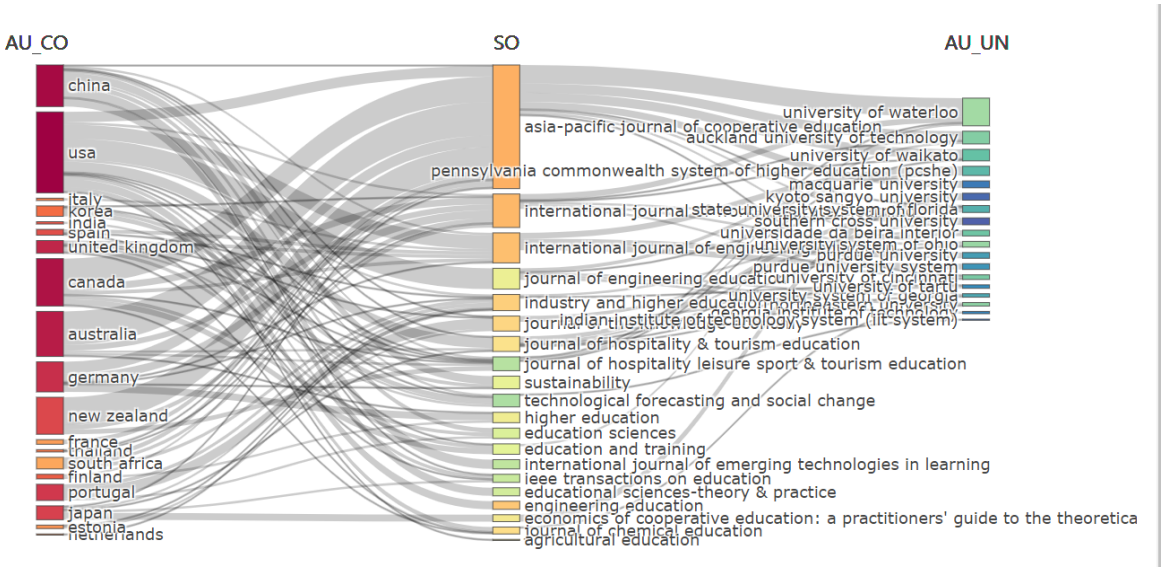

Figure 7(a). Three-Fields Plot among countries, journals and institutions using R-biblioshiny

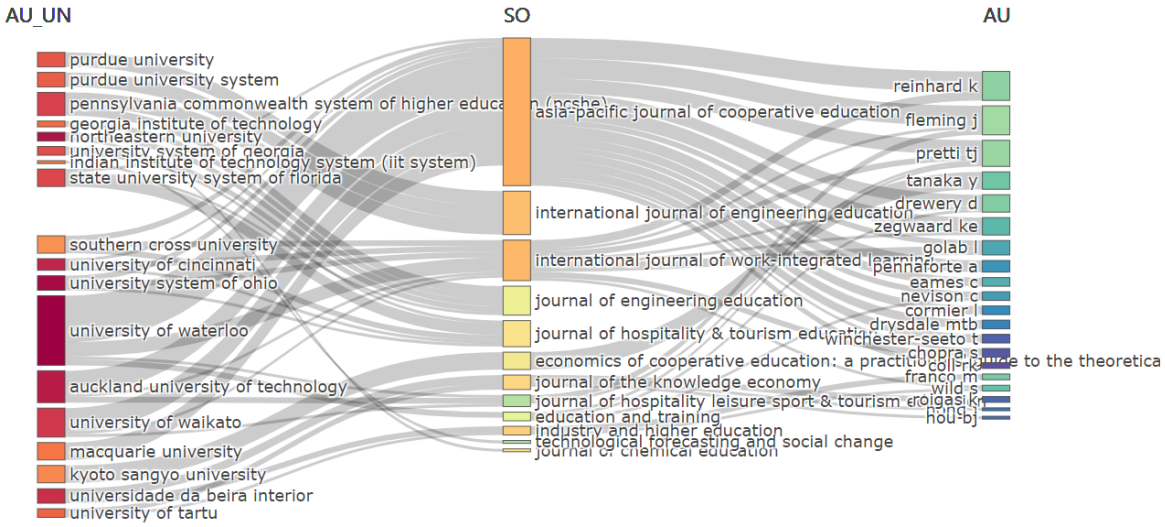

Figure 7(b). Three-Fields plot among institutions, journals and authors using R-biblioshiny

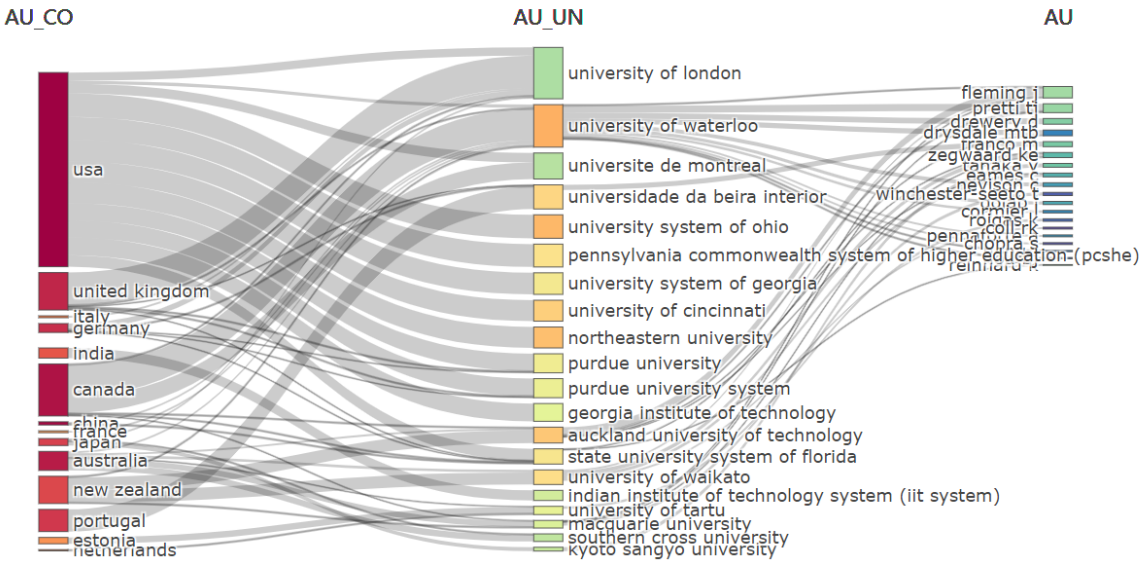

Figure 7(c). Three-Fields plot among countries, institutions and authors using R-biblioshiny

4.5. Analysis Results of Themes and Trends

Keywords appearing more than 5 times in the WoS core database were included in the final analysis. There was a total of 2,069 keywords, of which 95 met the threshold. In network visualization, the main theme within the blue cluster is “cooperative education”, which appeared 133 times with a total link strength of 324. Closely related themes include “work-integrated learning.” The theme of the red cluster is “innovation,” appearing 52 times with a total link strength of 230. Closely related themes include “university cooperation” and “knowledge transfer.” The main themes of the yellow cluster are “education,” “partnership”, “employability”, and “industry.” The green cluster includes “internship,” “experience,” and “work”. The purple cluster includes “university”, “higher education”, “barriers”, “challenges”, and “sustainability” (Figure 8). Based on the analysis of keyword co-occurrence and each article’s abstract, research related to university-industry collaboration is distributed across five clusters: (3) cooperative education and learning outcomes (1) innovation and technology transfer (4) collaboration models and partnerships (2) internships and work experience (5) collaboration barriers, challenges and sustainability.

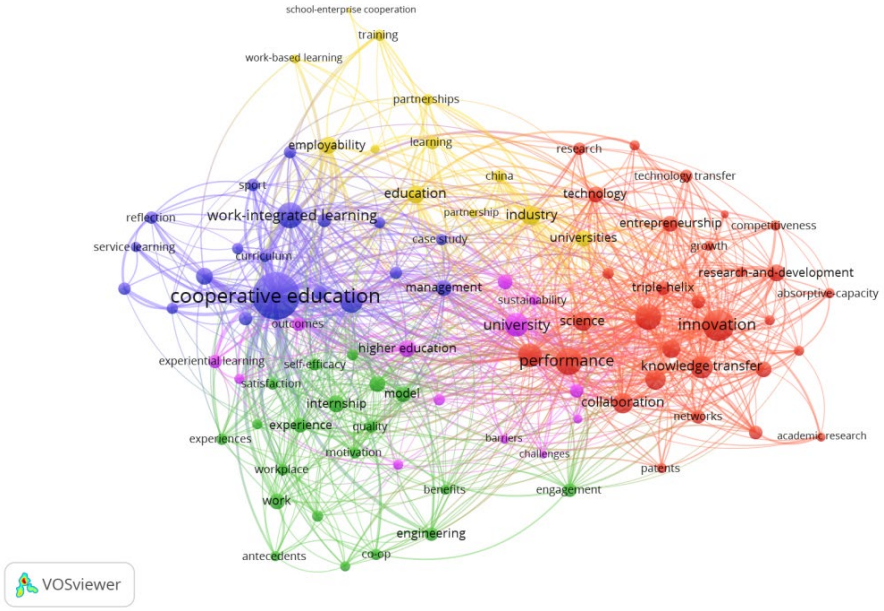

Figure 8. Analysis of the keywords in publications on "university-industry" : co-occurrence of keywords.

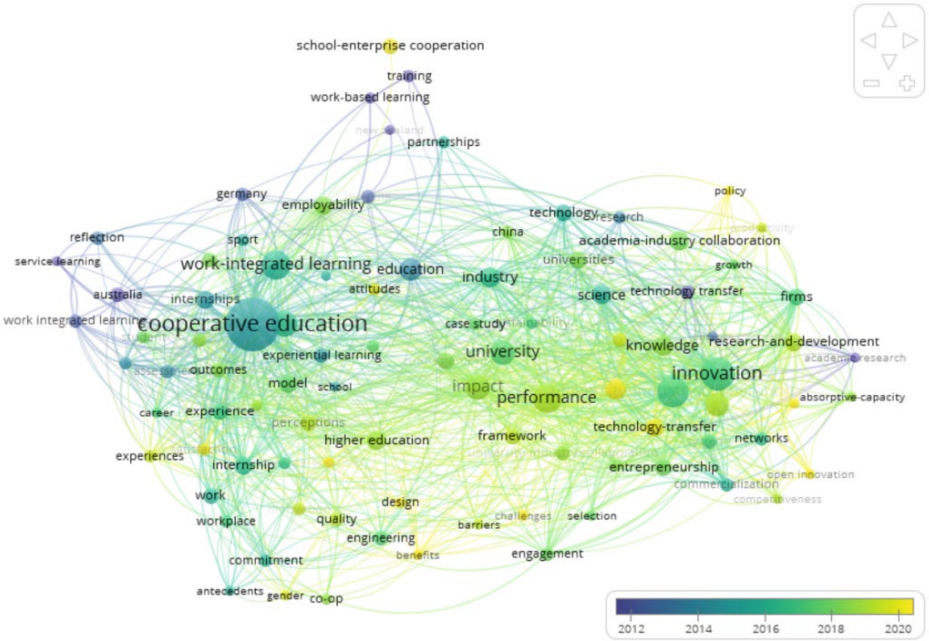

Figure 9. Network map of trending topics according to the co-occurrence of keywords.

The overlay visualization underscores the progression of research on this subject. Figure 9 shows the network map of the topics according to keywords applied from 2012 to 2020. All indicators in the figure show the most recent publications from green to yellow. The major occurrences of "cooperative education", "innovation", "work-integrated learning", "university-industry cooperation", "industry" represented by green are concentrated in the average year of 2014 to 2017. The latest research topics represented by yellow, such as " technology-transfer" , "triple-helix", " barriers", "benefits", "challenges", "motivations", "policy", "school-enterprise", "empirical-evidence" and so on, occurred after 2020, which means More studies focusing on these topics have been published recently. Other colors for research events indicate the years before 2012, or even older.

4.6 Analysis of Interdisciplinary Collaboration Evolution

Based on co-citation analysis, Cluster 1 in the shared references data mainly involves education and psychology, containing important literature on learning theories and educational practices (Dewey, 1986; Kolb, 2000; Vygotsky & Cole, 1978). Cluster 2, on the other hand, focuses on university-industry collaboration, innovation, and technology transfer fields (Bruneel et al., 2010; Etzkowitz & Leydesdorff, 2000; Perkmann et al., 2013). Combining this with the analysis from the Network map of trending topics shown in Figure 9, we can draw the following conclusions:

From 1970 to 1985, foundational research in education and psychology dominated, emphasizing learning theories and educational methods. From 1986 to 2000, with globalization and technological advancements, university-industry collaboration began to rise, shifting the research focus towards innovation. Between 2001 and 2010, interdisciplinary collaboration significantly increased, with a tighter integration between educational practices and industrial applications. From 2011 to 2015, research further deepened, emphasizing the role of universities in the innovation ecosystem. From 2016 to 2023, technology transfer and cooperative education became hot topics, reflecting the increasingly close collaboration between academia and industry.

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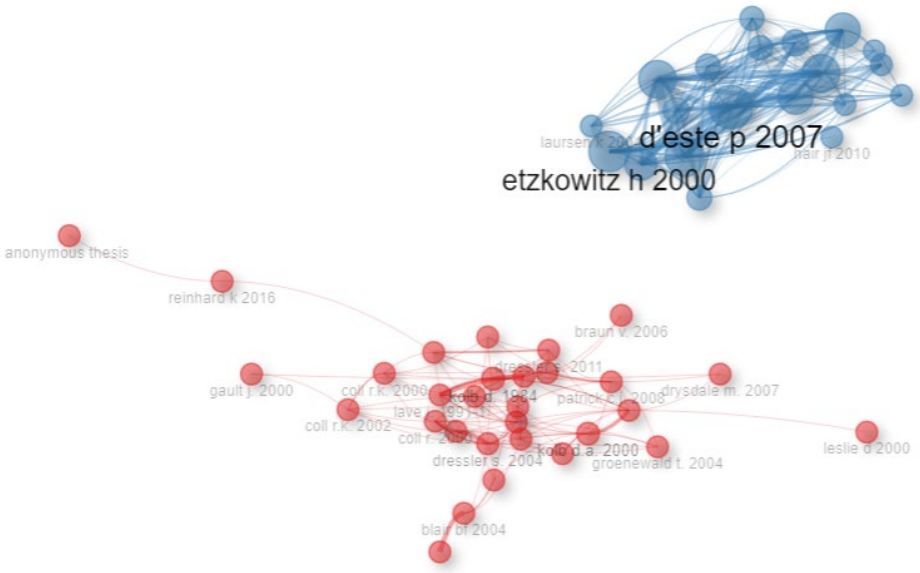

Figure 10. Co-citation network using R-biblioshiny

5. Discussion

The overview results reveal that scholars started researching university-industry collaboration in the 1970s. Over the past decade (2014-2023), although the number of publications has fluctuated, it generally shows an increasing trend. In the recent decade, the number of articles published in this field is 332, surpassing more than half of the overall publication count. This is closely related to several factors: universities becoming more flexible, increased active involvement of industrial partners, heightened government attention, and researchers in new economic entities (such as China) beginning to focus (Borges et al., 2022). These trends reflect the growing recognition of the importance of university-industry collaboration in driving economic growth and innovation. The heightened government attention and policy support in various countries likely played a significant role in encouraging these partnerships. Additionally, the global shift towards a knowledge-based economy has underscored the need for more effective mechanisms for knowledge transfer and innovation, further propelling interest and research in this field.

The conclusions drawn in this study align with previous literature reviews, confirming the positive role of university-industry collaboration in promoting knowledge transfer and innovation (Geuna & Muscio, 2009; Mascarenhas et al., 2018; Perkmann & Walsh, 2007; Skute et al., 2019). However, by expanding the search terms, this study identifies four additional perspectives that have garnered scholarly attention: student internships and work experiences, cooperative education and outcomes, university-industry collaboration models and partnerships, as well as collaboration barriers, challenges, and sustainability. Five clusters of studies comprehensively analyze the dynamic nature of university-industry collaboration.

The top journals, organizations, authors, and countries associated with university-industry collaboration provide valuable insights into the key players and contributors in this area of research. For instance, the Asia Pacific Journal of Cooperative Education emerges as the leading journal in terms of the number of publications, while the University of Waterloo stands out as the most prolific institution. Notably, authors like Jenny Fleming and organizations like the University of Waterloo have made substantial contributions to the literature, reflecting their significant influence in shaping research in this field.

Furthermore, the analysis of keywords reveals the evolving themes and trends in university-industry collaboration research. Topics such as cooperative education, innovation, work-integrated learning, and knowledge transfer as prominent themes, indicating the multidimensional nature of research in this domain. Recent research themes include “technology transfer”, “triple helix”, “barriers”, “benefits”, “challenges”, “motivations”, “policy”, “school-enterprise”, and “empirical evidence”. knowledge transfer mechanism, governmental factors, organizational design factors, technology transfer and the collaborative network has a significant impact on strengthening UIC (Kamal et al., 2023). Among the recent research topics, the investigation of barriers, benefits, and challenges associated with university-industry collaboration stands out as particularly noteworthy. Scholars have sought to identify and address obstacles hindering effective collaboration, while also highlighting the potential advantages and opportunities that arise from successful partnerships between universities and industries. Though previous research has identified both barriers and facilitators of university–industry collaborations. However, our current understanding of the

evolution of these collaborations remains limited, thereby impeding our ability to effectively cultivate their development (O'Dwyer et al., 2023).

By the analysis of interdisciplinary collaboration evolution, it is evident that interdisciplinary collaboration has evolved from single-discipline research to multidisciplinary integration, particularly in the fields of education, innovation, and technology transfer. This evolution not only drives theoretical advancements but also promotes practical applications, forming a comprehensive, collaborative research ecosystem.

Scholars have covered multiple perspectives, including those of universities, industries, and students. It is noteworthy that research from the industry perspective is relatively limited, providing new avenues for future studies. Delving into the motivations, obstacles, and responses to government policies faced by enterprises engaged in university-industry collaboration can provide a more comprehensive understanding of various dimensions, laying a solid foundation for practical applications.

6. Research limitations

This study retrieved publications on the theme of university-industry collaboration from WoS and conducted an objective and comprehensive analysis of the data. However, limitations are inevitable. Firstly, using specific criteria (English language, articles and review articles) may lead to overlooking high-quality literature on the topic in other languages, potentially resulting in biased outcomes. Secondly, the citation frequency in indexed literature is influenced by time. Recently published papers, due to their shorter time since publication, may have lower citation counts, leading to discrepancies between research results and the actual scenario. Thirdly, relying solely on the WoS database for visual analysis may introduce bias into the results. It would be beneficial to include other databases such as Scopus, PubMed, etc., for a more comprehensive analysis, as otherwise, many important articles might be excluded. Fourthly, despite the researchers categorizing and reviewing the literature on university-industry collaboration in WoS, there are still some publications that, due to the specificity of their research topics, could not be classified.

7. Conclusions

University-industry collaboration is an area of great attention and continuous development (Skute et al., 2019). Researchers, through in-depth studies on its functions, models, motivations, obstacles, and other aspects, have revealed the complexity of this collaboration. In recent years, research on university-industry collaboration has shown a trend towards diversity and global relevance (Mascarenhas et al., 2018). Factors such as innovation, economic development, and learning models have propelled the deepening of school-enterprise collaboration. However, accompanying this progress are various obstacles, including issues of trust, organizational cultural differences, intellectual property disputes, geographical constraints, and others, all of which require comprehensive solutions.

Despite significant advancements, there are still directions worthy of further research. For instance, research on collaboration in the field of vocational education is relatively limited, and there is a need for a deeper understanding of collaborative models in different countries and cultural contexts, as well as more in-depth studies from an industrial perspective. Therefore, future research can focus on filling these knowledge gaps to further advance the field of university-industry collaboration. In conclusion, research in this area provides valuable insights for policymakers, educators, and industries, and holds the potential to play an active role in promoting innovation and enhancing economic competitiveness.

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